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MARCH 2015
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SILICON CHIP MAR '14 KC-5527

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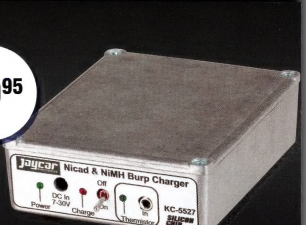
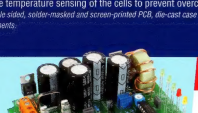
Kit supplied with double sided, solder-masked and screen-printed PCB, die-cast case (110 x 94 x 340mm), label, and electronic components.

$79.95



POWER KITS



$129

12V 120W 3-Step MPPT Solar Charge Controller

SILICON CHIP FEB '11 KC-5500

Charge controllers are essential for solar setups, although commercial units can run into several hundred dollars. Designed for use with 40W to 120W 12V solar panels and lead acid batteries, this solar charge controller kit provides 3-stage charging with the option of equalisation and with MPPT (Maximum Power Point Tracking). Operation is for 12V panels and batteries, but a 24V upgrade will be available in future.

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- PCB: 111 x 85mm

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- PCB: 72 x 30mm

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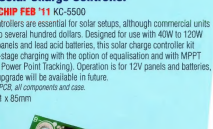
SILICON CHIP MAR '04 KC-5391

This great little converter allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or Alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, the kit will pay for itself in no-time! You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell. *Kit includes PCB, and all electronic components.*

- PCB: 59 x 29mm



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Battery Saver Kit

FOR RECHARGEABLE LITHIUM AND SLA BATTERIES

SILICON CHIP SEP '13 KC-5523

This tiny circuit fits in between the battery and load and cuts off the power when the battery becomes flat to prevent the battery over-discharging and becoming damaged. Suitable for use with cordless power tools, emergency lights, small to medium UPS (up to about 300VA) and a wide variety of other devices. *Kit supplied with double sided, solder-masked and screen-printed PCB with SMDs pre-soldered, voltage setting diodes and resistors, and components.*

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SILICON CHIP MAY '07 KC-5446

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RECOMMENDED BOX HB-6015 **$2.95**

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SILICON CHIP MAY '08 KC-5463

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LED Battery Voltage Indicator Kit

ELECTRONICS AUSTRALIA SEP '95 KA-1778

This tiny circuit measures just 25mm x 25mm and will provide power indication and low voltage indication using a bi-colour LED, and can be used in just about any piece of battery operated equipment. Current consumption is only 3mA at 6V and 8mA at 10V and the circuit is suitable for equipment powered from about 6-30VDC.

Kit includes PCB, bi-colour LED and all components.

- PCB: 25 x 24mm

DC RELAY KITS

$9.95

12VDC Relay Card Kit

KG-9142

This kit will close a relay's contacts with as little as 5mA to trigger the circuit. Literately any kit you see on these pages that uses an LED as a trip-condition indicator, can be used with this nifty project. Use the relay to sound buzzers, switch on lights, operate solenoids, trigger alarms, etc. *Kit includes Kiwik Kit PCB, relay plus electronic components.*

- PCB: 45 x 17mm

$16.95

DC Relay Switch Kit

SILICON CHIP MAR '04 KC-5434

An extremely useful and versatile kit that enables you to use a tiny trigger current - as low as 400µA at 12V to switch up to 30A at 50VDC. It has an isolated input, and is suitable for a variety of triggering options, including an AC or oscillating signal. It also has a relay-on LED indicator. *Kit includes PCB with overlay and all electronic components.*

- PCB: 61 x 46mm

RECOMMENDED BOX HB-6015 **$2.95**

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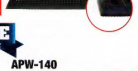

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Publisher's Letter

Going off-grid: is it worthwhile?

One of the letters in the Mailbag pages in this month's issue is on the question of "going off-grid". This is an option being looked at longingly by many electricity consumers as they are confronted by ever-higher quarterly bills and if they have solar panels on their roof, the prospect of diminishing solar feed-in tariffs as time goes on.

What might have looked like a sure-fire investment just a few years ago, now looks somewhat diminished as various state governments have realised the threat to their budgets if they continued paying the originally generous solar feed-in tariffs to those in the vanguard of solar roof-top installations.

Furthermore, as more and more solar panels have been installed, it has become common in some areas for the mains voltage on hot sunny days to run up against the 250VAC (or thereabouts) threshold voltage of most grid-tied inverters and so they are throttled back to the point where they may generate very little or no power. The customer gets zero feed-in tariff when that occurs and to add insult to injury, depending on how their "smart" meter is arranged, they may also be paying peak tariff.

Finally, how many people with solar panels on their roof are severely frustrated when a blackout occurs? There are those wonderful panels on the roof, potentially able to generate all the power they need and then some, but because of the "anti-islanding" feature of grid-tied inverters, no power can be generated. To me, that must seem like a serious injustice. Wouldn't it be better if there was a facility for the "anti-islanding" feature to be turned off when blackouts occur and for the household to be temporarily disconnected from the grid so they could enjoy their own solar electricity? Alas, that is not so.

So can you blame such people for considering the options to go off the grid and be finally freed of those "mercenary" power companies? Trouble is, there are no easy options. For a start, you need a new inverter without the anti-islanding feature. Second, you probably need a lot more panels because most roof installations only have a capacity of a few kilowatts. You need a lot more than that to cater for the peak demand in a typical household, particularly if you want to run electric heating and/or air-conditioning.

And then there is the most expensive component of any off-grid electric installation – a big fat battery bank, because once you go "off-grid", you are literally on your own and you need to provide all of the electric energy needs all day, every day, at night time and whether the Sun is shining or not.

Of course, if something in your off-grid power system fails, you cannot simply phone your friendly (not so mercenary, perhaps?) power company and ask them to fix it. Nor, if you get sick of being on your own, will it necessarily be possible to be like the electric prodigal son to "repent and come back to the fold".

From time to time there are articles in the press about how much of our power generation will be "distributed" (meaning solar panels) rather than "concentrated" (in large remote power stations) in the future. And since so much of the power will be based on solar panels, storage in the form of batteries will be part of the deal. All of this is predicted to become viable quite soon because of the steadily reducing cost of lithium-based batteries. Of course, further into the future, there will be fantastic breakthroughs in battery technology such as the "double carbon" battery and we will all be in an electric Elysium without a care in the world.

Well, don't hold your breath. Developments in battery technology are following a similar path to the development of flat-screen TV sets. That went on for many decades and finally, yes, flat screens did come into production and of course today we have video nirvana, don't we?

Except that in the case of batteries, progress has been arguably slower. In fact, a century from now people might look back and wonder about all the effort to research batteries which ultimately was futile and unnecessary because of the historic break-through in fusion power generation? I am betting that such a breakthrough will occur, even though I probably won't be around to see it.

Leo Simpson

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Drive-by-wire systems are vulnerable

John Goswell (Mailbag, page 8, November 2014) and John Denham (page 12, December 2014) raise some serious concerns regarding the latest automotive "megalomaniac" design "disease", namely the obsession of foisting keyless entry and starting systems onto us all. Of concern is the increasing infiltration of "drive-by-wire" systems into every vehicle sub-system and the potential vulnerability to external interference – accidental or deliberate.

Of course, the regulators apply a whole spectrum of compliance standards to ensure safe and reliable operation. Indeed, I recall seeing on TV a most impressive live demonstration in Germany of a vehicle test (with a seated human driver on-board) while being zapped by 100's of kilovolt bolts of artificial lightning to determine the effects on the test vehicle's electronic systems. However, what is not clear is whether there is any mandated requirement for EMI-proofing the actual electronic key itself. Has anyone looked into this? After the reported spate of incidents, I bet they will be now.

By the way, this is not some off-the-cuff moot point: I remember reading of a reported "strange day" in Nevada some years ago when car security companies received a massive spike in distress calls from car owners reporting the failure of their electronic key fobs. Apparently, there was a nearby US military test facility where it was surmised that they had been conducting tests of EM pulse weapons. Needless to say, the US army would neither confirm nor deny.

I wonder how many drivers casually throw their keys on the kitchen counter in front of the microwave oven! For a parallel perspective on this, reread G. M.'s interesting article in the Serviceman's Log in the November 2014 issue.

On other matters, I was pretty disappointed by Ross Tester's article purporting to present the state-of-play of electric vehicles. Is he blind to the dramatic developments that have recently emerged on the EV battery research scene? In particular, the "Holy Grail", the double-carbon electrode battery. So sensational are the performance claims made for this battery that, if proven, it will completely transform the landscape for the inexorable penetration into mainstream use.

In fact (on the proviso that its performance claims are verified), I'm prepared to stick my neck out and say that future automotive historians will look back and write of a time before the double-carbon battery and a time after – so stark will the division line be. This, of course also has implications for the middle-ground, the tenuous space where hybrid vehicles currently "live". Consequently, the conclusions of the ID-TechEx report are wrong which inevitably means that hybrids, as a class, will get squeezed out. Google search under Power Japan Plus, double carbon battery for more information.

Andre Rousseau,
Papakura, NZ.

Comment: over the decades there have been many forecasts of breakthroughs in new battery technology. While lithium batteries of various types are a big step forward compared to other rechargeables, we have quite a long way to go. Perhaps the double-carbon electrode battery will be all that is promised. We will wait until it is commercially available.

How impact drivers work

I have just read the answer to "How do impact drivers develop such high torque" on page 101 of the January 2015 is of SILICON CHIP. The answer given is completely wrong.

The secret is in the word "impact". Other devices that develop amazingly high torques (or forces) include hammer drills, jack hammers and simple devices such as a hammer hammering in a nail, an axe chopping wood and a pile driver hammering in a pile.

In all these cases a relatively small force (or torque if the motion is a rotation) accelerates a mass over a certain time. The mass then impacts the object being driven and is slowed down in a very much shorter time. This results in a much larger force (or torque) being applied to the object being driven.

It is all related to Newton's Laws of motion and conservation of momentum. Taking a hammer as an example, use a medium hammer blow to push a nail into a piece of wood. Now try to simply push the nail in with a steady force. This will give some idea of the force the hammer head applied to the nail as it was being brought to rest.

Momentum change of driver = Force x Time. The motor supplies the force (torque) to accelerate the driver mass. This strikes the output section, the impact rapidly slows the driver mass and supplies the large force (torque). We could assume that the driver supplies 10 impacts/second, each impact lasting 1/500 second. So the maximum output torque will be about 50 times the average input torque.

This is why the "rattle gun" used to tighten your wheel nuts can be used with one hand (average input torque) but you need a wheel brace, two hands and a lot of grunt to undo them (maximum output torque).

Alan Torrens,
Hornsby, NSW.

Endorsement of Publisher's Letters

I loved your Publisher's Letter in the February 2015 issue, pointing to the horrors unleashed by rabid readers. Please do not stop writing your editorials or tone them down in any way as then the rabid ones win and we all lose.

Besides that I love seeing the pounding the Publisher gets in the Mailbag pages in the following months. It helps to make up for the pounding I got from him over my grammar and spelling errors back in the old days when writing my articles on Radio Control.

Speaking of the old days, your article "Reach for the Sky" in the same issue reminded me of my old mentor Sid Lake who worked for the CSIRO in around 1953. Sid had the remains of one of Dr Bowen's gliders which were released from balloons at North Head, Sydney. These were no ordinary model gliders. They were all aluminium from memory and shaped very much like a small German V1 buzz-bomb and I was fascinated by them.

They stored atmospheric data from the high-altitude balloon flights and were released from the balloon and guided back to North Head under radio control. It was this experience that convinced me that radio-controlled aircraft had a valid role to play in modern society and helped to launch me on my career in the radio-control/RPV/UAV field.

By the way, it was a great experience working with the SILICON CHIP team and that period remains one of my treasured memories.

Bob Young,
Ex Silvertone Electronics.

Electronic fox lure required

There is about a 50% chance that foxes are becoming established in Tasmania. This will be a disaster for the wildlife if it happens. Attempts to catch them with a food-loaded trap are not working. Foxes like a live target.

I have had success catching them with sound. They get very excited if they hear another fox in their territory or the sound of an injured rabbit.

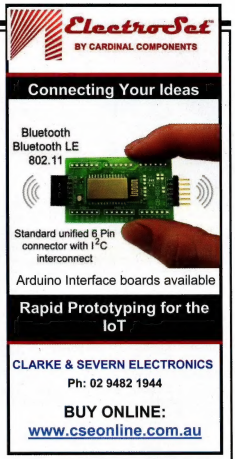
I would like someone who has an interest in saving wildlife and has the necessary skill to design a device that makes the necessary sounds at preset intervals. This device would have to be reasonably hifi and go up to about 30kHz but not high-powered as foxes have excellent hearing and we do not want to bother the public. The device would be waterproof and robust enough to take a nip from a fox. Could you ask your readers for ideas?

Eric Dodge,
Officer, Vic.

Criticism of Currawong Stereo Valve Amplifier

Performing a Google search with the subject "why are valve amplifiers so expensive", returns results along the lines of "the output transformers are large and expensive to manufacture". The Mullard publication "Circuits for Audio Amplifiers" (first published in April 1959), in the chapter titled "General Notes on Construction and Assembly" states: "The quality of the output transformer will govern to a great extent the quality of the output from the loudspeaker. A poor component can give rise to a high level of distortion and can cause instability".

Readers of the Vintage Radio section in the October 2014 edition of SILICON CHIP will have seen pictures of the large output transformers Malcolm Fowler fitted to his rebuilt Mullard 5-10 type amplifiers (this design was first published in August 1954). So what is the likely outcome of the Currawong valve amplifier using a physically small and



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Is going off-grid worthwhile?

I have six square metres of solar panels on my north-facing roof. I estimate they generate about 5kWh per day. We are light users and average about 8kWh per day. Our supplier has reduced my feed-in rate a couple of times in the three years I have been operating; it is now hardly worth it.

I am thinking of paying them back by increasing the solar panels to about 20 square metres and installing battery storage (which is getting cheaper and cheaper) and going off grid. The main problem I see is insurance.

A large battery could be dangerous and there might be a failure in emergency communication. Can you or perhaps your readers advise me?

Jim Jacobs,
Engadine, NSW.

Comment: we cannot advise you about insurance. Possibly a licensed installer would be the best qualified to give this advice. However, going off-grid will require a different and higher-rated inverter, an MPPT charge controller and the abovementioned big battery bank. You need to thoroughly check out the cost/benefits before worrying too much about insurance.

Mailbag: continued

cheap ($11.95 retail) 15W 100V line PA transformer as the output transformer?

The transformer EMF equation is **E(rms) ~ 4.44 NfaB(pk)** where *N* is the number of turns, *f* is the frequency in Hz, *a* is core cross-sectional area in square meters and *B(pk)* is the peak magnetic flux density in Tesla.

Note that voltage is proportional to frequency and core area for a given flux density and number of turns. The core will have a maximum flux density that can be handled. Beyond this level, the core "saturates" and the voltage will reach a maximum. For hifi valve output transformer applications where low distortion is required, the transformer core must be operated in the linear region well below saturation. By using a larger core area (ie, a larger transformer), the same output can be obtained at a lower flux density and will result in lower distortion.

The Mullard book specified that the "power response" for the prototype 5-10 amplifier was flat within 1dB from 20Hz to 15kHz. So at 20Hz, 8W (-1dB from 10W) is the rated maximum output power. At 30Hz, with the same flux density in the transformer, the maximum transformer output voltage will be 1.5 (30Hz/20Hz) times larger. So the power handling capability of the output transformer at 30Hz will be 2.25 times higher than at 20Hz (since power is proportional to voltage squared). So for the same level of distortion, the transformer will therefore be able to handle 18W at 30Hz.

Since the amplifier is only rated at 10W, the full 10W of output will be available at 30Hz, the output transformer no longer being the limiting factor.

Looking at the specifications of the Currawong amplifier on page 30 of the November 2014 edition of SILICON CHIP, the output power is listed as 2 x 10W at 8 ohms, with no information as to the frequency range over which this output can be achieved. Readers are referred to a power output versus distortion graph measured at 1kHz. Readers unfamiliar with valve amplifiers could therefore quite reasonably expect that 10W per channel is available over almost all the frequency range given by the specified frequency response, as would be the case with a direct-coupled solid-state amplifier.

Astute readers may notice from Fig.4 on page 37 (which shows distortion versus frequency at 1W output) that for an 8-ohm load the distortion level at 30Hz is approximately 1%. The rise in distortion as the frequency is reduced from 40Hz is quite steep and suggests that the magnetic flux density in the transformer core is heading towards the saturation point.

At 60Hz, with the same flux density as at 30Hz and the same amount of negative feedback, 4W should be available at 1% distortion and at 90Hz, 9W should be available. The 15W rating of the output transformer will be achieved at approximately 120Hz. These results should not be surprising since most 100V line PA speakers will likely have very little output below 100Hz.

SILICON CHIP has presented a design for a valve PA amplifier and not clearly disclosed the fact that the available power output at less than 1% distortion at frequencies below 90Hz is lower than the rated 10W. Hopefully some

time in the future, having "cut your teeth" with this design, SILICON CHIP can produce a valve amplifier using an output transformer that is rated for hifi usage and at least capable of full output at 30Hz as was the Mullard 5-10 Amplifier of 60 years ago.

There is also an error in the text of the November issue regarding the high-voltage rectifier circuit. While the two diodes are half-wave rectifiers, convention classifies rectifier circuits from the transformer's perspective. Current is drawn from the transformer during both the positive and negative cycles of the AC waveform so the circuit given is described as a full-wave voltage doubler.

Ian May,
Para Hills, SA.

Comment: your statements are correct and are backed up by the article on the Currawong elsewhere in this issue which compares the performance of the specified 100V line transformer with a very expensive Hashimoto transformer – it does have a big core!

Comments on USB scope shoot-out

With respect to the 3-way USB Scope Shoot-out article in the February 2015 issue, I really appreciate the author's effort in preparing such an excellent review. I only have a very minor comment on the pre-trigger and post-trigger issue of our product, the Virtins VT DSO-2820R:

(1) the fifth pargraph of page 73: ". . . trigger delay adjustable anywhere between the start (-100%) and finish (+100%) of the record length (normally the delay is set to 0%, or the centre of the record . . ."

(2) the last paragraph of page 78: ". . . with the Virtins DSO-2820R, there is no facility for moving the trigger point in from the lefthand side of the display (ie, no pre-trigger display) . . . ".

Actually, the VT DSO-2820R supports pre-trigger (-100% ~ 0% of Record Length) and post-trigger (0 ~ 100% of Record Length). The trigger delay can be negative, 0 or positive delay with reference to the trigger point.

By default, the trigger delay is set to zero and the trigger point is at the left most of the X axis. It can be adjusted either through the Trigger Delay spin box on the Trigger Parameter toolbar or by dragging the trigger delay mark (pre-trigger only) at the upper left corner of the oscillograph.

David Wang, Sales Manager,
Virtins Technology Ltd,
Singapore.

Omega VLF radio tower to be demolished

Readers may not be aware that the Omega VLF Tower in Woodside, Victoria, featured in the September 2014 issue of SILICON CHIP, is scheduled to be demolished, apparently due to the fact that a BASE jumper who illegally climbed on the tower killed himself jumping off it.

Of course, this was not the fault of the tower but Darren Chester, MP, Member for Gippsland and Parliamentary Secretary for the Minister of Defence has announced that the tower is to be destroyed. This would be a great shame because of the historical importance of the Omega Navigation System and the fact that it is an important local landmark or tourist attraction and one of only two remaining Omega towers in the world. The other remaining tower is former Station D at La Moure, North Dakota which was turned into a submarine communications facility.

It would be a terrible loss to Australia's and the world's radio and navigation heritage. Concerned readers may wish to contact Darren Chester at www.darrenchester.com/contact

A video of the tower can be seen at "Woodside Omega Navigation System Tower VLF Transmitter, Victoria, Australia", www.youtube.com/watch?v=S_T7hd0oXUE

A press story on the announcement can be seen at www.gippslandtimes.com.au/story/2802377/end-for-omega-tower/

Dr David Maddison,
Toorak, Vic.

Possible improvements to the Currawong

Over the years, I have built quite a number of amplifiers and I would like to suggest some small modifications to improve what is already a very good system.

With regard to the phase splitter, this stage works best if the long-tail resistor is half the value of the plate resistor. Bias is provided by a small

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Mailbag: continued

Climate change & technology

With regard to the Publisher's Letter in the February 2015 issue, I don't fully agree with your policy that peripheral electrical/electronic subjects should be covered in SILICON CHIP magazine. I don't buy it for that. It reminds me of when Choice started to have a large number of "Green" articles. I wrote and said I didn't buy Choice for green articles. They stopped (largely).

One aspect of climate change (about which I'm happy to be called a sceptic) that has an electronic/engineering dimension is how the temperature of the Earth (absolutely or relatively) can be meaningfully defined – to within a few degrees, let alone tenths or hundredths of degrees.

The definition has to include the atmosphere somehow or other I would think, not just the surface. And whether one averages daily maximum and minimum for a daily figure – and why. And how to average say seaside/sea-level Sydney with inland/altitude Canberra?

Assuming a definition can be agreed somehow, how can meaningful measurements be made to within tenths or hundredths of degrees, even at ground level, let alone altitude? And assuming all the above can be done, how can today's measurements be melded with historical numbers?

And finally, why are solutions to possible future problems only looked at in the context of today's technologies? SILICON CHIP readers, especially the older ones, have seen enormous technological changes contributing to improved quality of life for many if not most.

Surely it is at least equally appropriate to be optimistic rather than pessimistic about the future ingenuity of the human race in mitigating any problems and coming up with brand new solutions and initiatives. This seems far more likely to me, as a retired engineer, compared with any problems which might flow from unlikely, small temperature rises in some places.

Mike Dinn,
Canberra, ACT.

resistor connected to the cathodes. The grid resistor of the second stage is connected to the junction of the bias resistor and the tail resistor. This grid is bypassed to earth. The stage exhibits some unbalance and it is usual for the second stage plate resistor to be 5-10% higher than that of the first stage.

As the grids run at about half voltage, the input can be direct-coupled to the first stage, allowing the removal of one coupling network and hence reducing phase shift around the loop.

For the input stage, a single 12AX7 section can replace the feedback pair. The second section can, for practical purposes, be ignored. The non-use of the second stage allows removal of a number of components and also removes a second coupling network and the local feedback loop, further improving the phase characteristics. This would be particularly useful at low frequencies with the output transformer used.

Putting a series capacitor in the feedback line in effect adds bass boost to the system. A better system is to use DC feedback and split the resistor into two, bypassing one half to give a measure of gain reduction at the higher frequencies. Another useful addition is to add a series RC network across the plate resistor of the first stage to reduce loop gain at high frequencies.

With the output valves, by linking the cathodes (using pin connectors and a removable wire link between the test points for set-up) you will introduce local feedback and improve AC balance. The bypass capacitors can also be eliminated.

The grid resistors of the output valves should never exceed 500kΩ and preferably can be as low as 100kΩ, to avoid any shift in operating point due to grid current (the larger the valve, the bigger the current.) The coupling capacitors would need to be increased to compensate.

To improve DC balance, you can supply an adjustable voltage from the 12V supply to the bottom of each grid resistor.

Finally, the usage of headphones has changed over the years. With the advent of wireless systems, they are mainly used by the hard of hearing and hence are in addition to the normal listener. This means that the speakers do not need to be disconnected. The connecting socket could even be at the amplifier input, as these phones have their own amplifiers and volume control.

David Tuck,
Yallourn North, Vic.

Comment: many of these suggestions represent a departure from the normal practice in highly regarded valve amplifier such as those by Mullard, Williamson etc. We would warn readers against making piece-meal changes to the circuit unless they have the means to measure harmonic distortion and thereby judge the effect of any modifications.

Keep the Publisher's Letters coming

I read the Publisher's Letter in the February 2015 issue with some wry amusement. I'll admit to wanting to wring his neck at times but he would not be doing his job if he didn't make people think!

As you say, SILICON CHIP is one of the very few electronics magazines left in the world and I've certainly seen them come and go. Keep it up.

Dave Horsfall DTM, VK2KFU,
North Gosford, NSW.

Reasons for speaker transformer failures

Regarding the Vintage Radio column for November 2014, I'd like to make a comment concerning speaker transformer failures. Contrary to the author's opinion, I have found it is usually not excess current but electrolysis that causes an open-circuit primary.

The problem is that with 250V DC superimposed on the primary winding, any leakage to the earthed core causes a minute current to flow which then eats away at the winding. Depending on the quality of the enamel and how the wire has been handled, the insulation of the winding wire is not always perfect.

The paper bobbins and insulation used in most old valve output trans-

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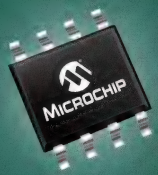

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Mailbag: continued

Science can be used for good or evil

Science is an amoral human invention – it can be used for good or bad. Science flourishes under any regime that will fund it. There are amoral scientists who will work on any project for any regime that will fund them.

Scientists are subject to social, political, ideological, funding and status pressures just like any human. Scientists have manipulated data and results for a variety of ulterior motives. Scientists will remain silent on any item if to speak out will threaten their status, funding or position.

To say that the science of global warming is settled is nonsense – the science of a prediction is not settled even if the predicted happens because the scientists' job is then to show that what happened was because of what was predicted, or that it came about because of confounding variables or previously unknown factors. A degree of scepticism is healthy in all of us on all matters, including those who believe in science or scientism or statistics or government.

Leonard D. Long,
Trinity Gardens, SA.

formers is of course hygroscopic and thus a leakage path can exist. The worst example of this I have seen was when I rewound the vertical output transformer from a 1958 Philips valve TV set. Right through the entire length of the winding, which consisted of about 3000 turns of 39-gauge wire, there were verdigris spots every few inches.

Various schemes have been used to try to overcome the problem. Apart from the obvious ones of trying to prevent moisture entry, the most effective was to simply connect the transformer core to the B+ supply, thus removing the potential difference. Probably the most well known transformers using this method were the "Isocore" models manufactured by Rola. With these, the live core was mounted in a can filled with pitch which insulated the core from the can, as well as providing resistance to moisture.

However, not all transformers with the core connected to the B+ were so insulated and those new to valve electronics should be aware of this due to the shock hazard. One common method was to simply mount a conventional open-frame transformer on an insulated Paxolin panel and connect the frame straight to B+.

For those bothered about the possibility of receiving an unpleasant shock from touching the transformer, an option is to connect the transformer frame via a high value resistor, say 1MΩ. As no significant current is drawn, the core remains at B+ potential to reduce electrolysis but not enough current can flow to cause a shock hazard.

AWA manufactured a speaker transformer during the 1960s which also had a live core. Unless one looks closely, this is not obvious because the open construction and mounting clamp are like that used for any conventional transformer. Closer examination reveals one of the primary terminals connected to the core with strips of paper providing isolation from the mounting clamp.

Once plastic bobbins came into use with their superior insulating qualities, the problem of open circuit speaker transformers was almost eliminated.

As for the possibility of excess plate current burning out the speaker transformer in a domestic radio, as a result of inadequate bias, I have found it to be a very rare event. For one thing, the DC resistance of the primary is low; typically around 500 ohms. Even if the plate current of the output valve, typically 40mA, increased to, say, 100mA because of a leaky grid capacitor, the power dissipation over the entire winding would only be 5W, which spread over a few thousand turns is quite harmless.

In reality, the current of the output valve does not usually increase to such destructive levels when the coupling capacitor becomes leaky. The cathode or back bias used in most receivers automatically increases, offsetting the increased plate current to some degree. In extreme cases, the cathode resistor burns out and its bypass electrolytic explodes, stopping the flow of current.

The other thing to keep in mind is that in a typical domestic receiver, the power supply is poorly regulated. With a thermionic rectifier and the resistance of a filter choke in circuit, the current will be further limited.

One event that can damage a speaker transformer is where it becomes effectively connected across the B+ rail. If the output valve has a plate bypass or tone control capacitor connected between it and earth and the capacitor shorts, the transformer is effectively connected straight across the B+ supply. The current is then limited only by what the power supply can provide.

The correct thing to do is to have the capacitor across the speaker transformer primary. Not only has the capacitor less voltage stress but if it fails short circuit, it will do no harm to any other component. An output valve with an internal short can also damage the transformer in the same way. I can only recall one instance in recent years which was in one of my Ekco TV sets where the PL82 audio output valve had shorted, destroying the transformer as well as the cathode bias components.

I am a firm believer in fuses and fusible resistors and find them effective in saving what are sometimes rare and costly components. In my opinion, the inclusion of a fuse in a radio restoration is far more important than the obsession with installing 3-core power cables with "approved" clamping methods to satisfy the Nanny State. An inline fuseholder avoids any irreversible or cosmetic modification to the set.

Mention was also made in the article concerning the absence of a standard mains polarity when using a bayonet light socket as the source of power. However, it wasn't just light sockets. Power points did not have an official standard as to polarity until much later on. From what I have seen, this appears to have been in the 1960s.

The only stipulation was that the Active conductor was switched at the power point. Remember, this was the era of a separate switch and socket mounted on a 3 x 6-inch pine block, so although the Active was switched, the socket could be wired either way. Aside from this, there were some English and American 2-pin power points in still in use.

Whilst still on valve technology, needless to say I was pleased to see your new valve amplifier project. I will be the first to agree that something along the lines of your solid-state class-A design would give superior performance. The measurements are undeniable. However, the attraction

Passionate beliefs may not be soundly based

With respect to the Publisher's Letter in the February 2015 issue, on the subject of passionately held beliefs, whether in climate change, wind power, solar power, nuclear power etc, the following extract from the philosopher Bertrand Russell's essay "On the Value of Scepticism" could be helpful.

He writes: "There are matters about which those who have investigated them are agreed; the dates of eclipses may serve as an illustration. There are other matters about which experts are not agreed. Even when the experts all agree they may well be mistaken. Einstein's view as to the magnitude of the deflection of light by gravitation would have been rejected by all experts, yet it proved to be right.

Nevertheless, the opinion of experts, when it is unanimous, must be accepted by non-experts as more likely to be right than the opposite opinion. The scepticism that I advocate amounts only to this: (1) that when the experts are agreed, the opposite opinion cannot be held to be certain; (2) that when they are not agreed, no opinion can be regarded as certain by a non-expert; and (3) that when they all hold that no sufficient grounds for a positive opinion exist, the ordinary man would do well to suspend his judgement.

When there are rational grounds for an opinion, people are content to set them forth and wait for them to operate. In such cases, people do not hold their opinions with passion, they hold them calmly and set forth their reasons quietly. The opinions that are held with passion are those for which no good ground exists; indeed, the passion is the measure of the holder's lack of rational conviction."

Bill Smith,
Glen Iris, Vic.

Mailbag: continued

Li'l Pulser is too complicated

With respect to the item on the "Model Train Control With Inertia" (SILICON CHIP, March 2015), let me say that I fully support the comments on the Li'l Pulser, having built many of the Mk.1's and two of the Mk.2 version. However, I do not agree with the comments in regard to the motor speed controllers not being suitable as model train controllers (I appreciate that you refer to the June 1997 design, so this is not a general comment). I should state that I belong to a model railway group.

The FK804M motor speed controller available from KitStop (Mosfet version) FK804M) teamed with the Altronics K63041 5A switching regulator has more or less been adopted by the group as the basic train controller.

Both of our display layouts use the PWM unit mounted in a small jiffy box with a 2-way centre-off switch and a red/green LED as the walk-around controller. Protected by a Polyswitch, it has survived several exhibitions and even a "U-Drive" layout operated by the young and old public!

As with the fix for Li'l Pulser Mk.2, you have gone over the top for a solution; the Polyswitch in series with one of the supply lines works every time for short circuit protection.

I agree that the Pulser design will give a much more realistic result than a switching regulator, if simulated inertia and braking are needed, That is one of the reasons I have built more than six of these kits over the years for my own use. I offered the Li'l Pulser design to the group but at about $130.00 (retail pricing) there were no takers. If buying wholesale parts from Altronics and the PCB from SILICON CHIP, the price was around $65.

Compare this to a KitStop PWM kit with changeover switch, LEDs and a Polyswitch for about $30.00 for which there were 15 takers!

So take away the inertia, braking, switching logic etc from the Li'l Pulser and you are left with a PWM circuit! I have added the variable voltage power supply so that the top speed can be limited – stops the "punters" crashing valuable engines and rolling stock.

Mike Abrams,
Capalaba, Qld.

is in the technology as well as all the other emotional/nostalgic aspects associated with valves.

In the end, if it sounds good then the design has achieved its goal and will provide much enjoyment. However, anyone who thinks it is a super-low distortion amplifier with superior frequency response is being delusional.

I'm well aware when I sit down to listen to my 1953 Philips radiogram with push-pull 6M5s that the mono sound emanating from it probably has one or two percent distortion, along with various peaks and troughs in the frequency response. But it sure sounds nice!

I have long been of the opinion that for a valve amplifier project to be popular for the masses, it would need to use 100V line transformers in the output stage and conventional easy-to-get low-voltage transformers in the power supply. I think that's what will make this project a winner compared to other magazine designs. For many years, I have taken this approach with some of my valve projects and have always achieved good results.

Note that some 100V line transformers do not work very well in single-ended output stages using pentode or beam-tetrode valves. From some brief experiments, this seems to be related more to insufficient inductance rather than DC saturation. Connecting the output valve as a triode usually solves the problem, although of course power output is reduced.

If I may offer a couple of comments on the Currawong design, perhaps triode operation of the output stage should be made as an option. It would be simple to implement with a couple of links and it would be interesting to compare the results with ultra linear operation.

Regarding the heater supply for the 6L6's, if one was fussy about heater voltage, it is very easy to bring up the supply to 12.6V AC simply by winding a few turns of hook-up wire through the core of the toroidal transformer and connecting it in phase with the existing 12V secondary. As it is however, the heaters are operating well within ratings.

It should be mentioned that the 6L6 is not designed for series heater circuits, which means that when used as such, the warm-up times and actual heater voltage may be slightly different between the two valves. However, as a matched pair is specified, this is not likely to be of any concern. I merely mention it for those who might use mismatched valves from random sources. It is simply a matter of adding shunt resistors across the heaters if the voltages need to be equalised.

I probably wouldn't have included the solid-state largesse of the power supply had I designed it but I fully support the reasoning behind it. If anyone is critical of it, there's nothing to stop them doing a tag-strip version of the amplifier using a power supply of their choice.

John Hunter,
Hazelbrook, NSW.

Advice on Engel fridges

With regard to the question about Engel fridges (Ask SILICON CHIP, November 2014, p104), recent models take a maximum of 50W on 230VAC mains while the maximum DC current is 4.2A on 12V; there is no inrush current.

If you use the Engel plug and dispense with the cigarette lighter part, it will run forever on a 7.5A auto fuse and 10A auto cable. The "original" Engels could take 6-7A but still ran OK on a 10A fuse and cable. My son is now using the heirloom 6A 40-year old one which has been bounced around in a 4WD for a lot of that time.

Our own needs now require one as a fridge and one as a freezer. We run both of these via a 100Ah battery in the truck and keep the caravan battery topped up using two 85W solar panels and your revised MPPT charge controller from the March 2012 issue of SILICON CHIP.

Jim Chrismas, MIET,
Gosnells, WA.

SC

Would you like to keep your home or business under 24/7 surveillance . . . from wherever you are (anywhere in the world!)?

Choosing, setting up and using IP Security Cameras

Wireless (IP) surveillance cameras, which operate over the internet, are incredibly common, come in a wide range of prices and are relatively simple to install and operate. With a 'net or mobile phone connection, you can see what's going on in your home or backyard – wherever you are – and even get a warning if the camera spots an intruder!

Many computer users, even those with a lot of experience, don't have any idea on where to start with these versatile devices.

They remember the bad old days, where installing a home security system was indeed a lot of hassle (particularly the wiring-in phase) and even when operating, often resulted in false alarms and more neighbourhood angst.

The days of running wires are so passé, with wireless systems now in vogue – but how many times have you heard an alarm sounding and thought "there's someone's alarm going off . . ." – but done nothing about it?

Many alarm systems don't even scare off intruders for that very reason: everyone will think it's a false alarm!

Enter camera security

Now there's a much better option – security or surveillance cameras which operate via the internet so you can keep an "eye" on your property 24 hours a day, 7 days a week, regardless of where you are.

Depending on the software driving them, many have the ability to detect and report intruders and just as importantly, record video for later analysis.

Some record locally, for example on a micro-SD card in the camera; others store (often temporarily) "in the cloud", which will be overwritten if not required after, say, a week or so.

Some are always on while others are triggered by detecting movement. Others use traditional home security triggering methods (beams, magnetic switches, pressure sensors etc) or even a combination of types.

The usual laws of purchase normally apply – the more you pay, the more features you'll get. But that's not always the case – there are quite a few cameras out there that are real bargains and offer quite exceptional features and performance!

But as we said earlier, many people think that setting such a system up has got to be (a) difficult, (b) expensive or (c) requires a lot of computer know-how. This article should help to dispel those three myths. Indeed, we hope to show you it is as simple as a-b-c!

Choosing a camera

There's an enormous range of cameras (and prices) available out there. We've shown a few on the following pages.

Some of the things to look for are:

By Ross Tester

(a) Resolution – full HD cameras usually cost more than standard definition. But if

At left is the Jaycar QC3831 IP Camera, mounted inside a weatherproof dome but under the eaves for complete protection. The power cable conveniently runs above the eave. Top right is the view you get through the camera, here displayed on YAWCAM (see later in this feature). At right is a similar image, using an EasyN camera and the EasyN Android app, accessed via the internet on a Samsung smartphone. You can tilt and pan the camera by swiping the smartphone screen from anywhere your phone has 'net access – even across the globe!

you want to identify faces, you want HD. We've all seen those awful, grainy old CCTV pictures on TV, where you can *almost* work out that it is a person but there's no hope of identifying a face! With modern cameras (including much improved lenses and optics), those days are thankfully well gone.

(b) Protection – is the camera really designed for 24/7 outside use where it is exposed to the elements, or is it more intended for either internal use or at worst, mounted in a protected position outside (eg, under the eaves)?

It will normally have a high "IP" rating to tell you what it suits. (See the panel "what does IP mean" elsewhere in this article).

You'll normally find exposed-use cameras cost quite a bit more than inside or protected cameras.

(c) Night vision. Most (but definitely not all) cameras these days are equipped with LEDs (usually infrared) to give a picture at night. Some even claim they work down to 0 lux – that's complete darkness, not even starlight!

And so they might but at what range? And how good is the night picture? Most will switch to B&W at night but for some, the image suffers significantly as well. Will it be good enough to identify an intruder?

(d) Audio. Is there an inbuilt microphone (or provision for an external one) to also pick up voices or animal sounds? It might be important.

(e) Ease of installation. We're not just talking ease of mounting (though that is important), we're also thinking about power supply. If it's a wireless system, that only means the data side is wireless – you usually still have to run a power cable which might not be convenient (will the cable reach from the power supply?)!

Some cameras, even wireless ones, offer PoE (power over Ethernet) but this still requires a cable to be run.

We've also seen some solar-panel-powered models which might solve some difficult installation problems.

(f) Operating system. Most cameras should have cross-platform support but there are exceptions. A few cameras are designed to operate on Android and/or Apple only, which is a problem if you only have Windows. Make sure the camera you select operates with your PC (or is equipped for all – fortunately, most are these days). In any case, you should be able to find third-party software – Ispy, for example – which should let a camera work with your PC.

(g) Features. This might seem self-explanatory but you need to know what features it (or its software) offers, such as whether the camera offers remote pan/tilt control, movement detection and/or auto notification as mentioned earlier. But there are other factors to consider – do your own research.

(h) Colour or mono. Most security cameras these days are colour, though the picture quality varies significantly. However, there are still plenty of mono cameras around so if you want colour, make sure it says so! Very few cameras stay in colour mode under low light (or when illuminating with their own LEDs).

(i) Price. We've left this until last. We've seen "wireless cameras" advertised online for absolutely ridiculous prices (eg, sub $5) but beware, these are usually fake cameras which contain nothing inside the dome or housing (they're

used to imply you have a camera – sort-of like the good old days when you installed an empty alarm box and put signs on the windows!).

There's also another neat scam where you click on a camera at a *real* bargain price, only to find you're buying a tiny part of it (eg, the antenna!). "Oh, you want the camera as well? Click here" (another $50 or $100!).

You might find a bargain wireless camera which is dependent on your also buying not-so-cheap "cloud storage".

And also be careful of "wireless cameras" which on closer examination aren't – not IP wireless (WiFi), that is. In fact, they aren't even computer camers – they are old-style CCTV cameras, designed to feed into a video monitor or recorder! (Some might use a wireless link to get back to the monitor/recorder but will not be able to access the internet; ie, they're not "IP" cameras).

OK, what should you pay?

Depending on where you purchase, you can easily pay several hundred dollars for a top-of-the-line, all-singing all-dancing wireless IP security camera; however the majority of cameras start at about $50 online – some even including postage (from China, of course!).

In a bricks-and-mortar store, you can usually expect up to double this for entry-level cameras. But buying over-the-counter from a store has several advantages – you can see exactly what you're getting, you (usually) have a money-back or at least exchange guarantee. And more often than not, there is someone in the store who is knowledgeable about the devices and can give you some good advice and guidance if you need it.

You certainly won't get most of those advantages buying online. So the choice is yours – save some money or save some anxiety!

Remember too the value of the assets you are trying to protect: is saving a few dollars worth risking many tens (or even hundreds) of thousands of dollars?

Location, location, location

The first law of real estate also applies to security cameras: where you set it/them up. Basically, it's common sense, Let's look at a few necessaries:

(1) Unobstructed view

This goes for what the camera lens "sees" and the path for the wireless signal.

You want a location which gives the best possible view. Sometimes it's necessary to compromise a little but if there are obstacles in the field of vision, intruders could use these to hide their approach.

Choose what you want to view carefully – external doors and windows are obvious but what about the Rolls-Royce in the garage? Hey, we've even heard of some people putting in a wireless camera solely to keep an eye on their pets while they're at work!

If there is anything solid in the path between the camera antenna and router, that could also be a problem for the wireless path. This especially applies to both brick walls and bushes/trees, which may not be too much of a problem in dry weather but can form very effective wireless shields when they are wet.

One way to check this is with a wireless network device (eg, smartphone or tablet). If the signal suffers where you

Jaycar QC3834

This pan & tilt camera is actually shown upside-down – it would normally be hanging on the bracket supplied. 0 lux illumination (up to 15m), 640 x 480 resolution and up to 50m line-of-sight WiFi range. Supports iPhone, iPad, Android smartphone and monitor. Currently reduced from $119.00.

$99.00

Fixed Indoor Dome (Jaycar QC3831)

Totally housed within a dome for protection; complete with 22 I/R LEDs for night viewing. Fixed aim only (ie no pan/tilt) even though it looks as though it can! 640 x 480 resolution @ 30fps, 60° viewing angle and has motion detection and remote warning. Access through a web browser (requires IE) or an iPhone/Android app.

$79.00

Outdoor Wired/Wireless (Jaycar QC3836)

Designed for outdoor use, complete with mounting bracket (not shown). Quick and easy setup, 640 x 480 resolution. Protective shroud shields camera and ring of IR LEDs for night viewing. (0 lux, up to 20m). Supports DDNS, which means you can access your camera through a fixed domain even if your external IP address constantly changes. (NB – reduced from $149, stock limited in some stores).

$119.00

TREK Ai-Ball (Jaycar QC3368)

Get it? Ai-Ball? At just 100g and 30mm diam. x 35mm long, it's the smallest wireless IP camera we've ever seen – even small enough to carry on your keychain! VGA (640 x 480) quality, powered by a single CR2 battery (or optional 5V supply*) and operates on WiFi (802.11b/g) via an internal antenna. See much more info at www.aiball.com

$99.95

***Optional cradle and stand with 5V power supply also available: QC3369 @ $29.90**

EasyN 640 x 480 (Altronics S9012)
Full remote viewing capability (with pan and tilt) over internet browser or smartphone. The camera features an embedded IR-Cut filter and an integrated network video recording system. Easy plug'n'play set up! 300,000 pixel sensor. As well as security applications, makes a great baby or pet monitor. 802.11b/g wireless and will support four viewers at one time. Includes microphone for audio monitoring and a power supply.

$89.95

EasyN Pan/Tilt (Altronics S9014)
A home surveillance IP camera with remote pan and tilt control. Easy plug-n-play setup allows you to view remotely in just minutes on most WiFi networks. High quality 720P resolution and H.264 compressed video. An SD card slot is on board for direct recording of footage. Speaker output and mic input available plus alarm trigger I/O terminals. 355° pan and 120° tilt. Includes power supply.

$175

IP65 Waterproof Aluminium (Altronics S9022)
With 1.0MP resolution (up to 1280 x 720), significantly higher than most cameras, it uses H.264/MJPEG compression to provide excellent picture quality and minimal storage requirements. IP65 rated for outside use, infrared LEDs provide night-time coverage up to 15m, and it will pan 355° and tilt 90°. Wireless suits 802.11b/g/n systems. Has alarm notification, FTP snapshot upload and event recording to TF card, operates on Microsoft Windows (XP, Vista, 7).

$235

AVTECH ETS (Altronics S9800)
A top-of-the-line vandal-proof day/night IP camera with infrared illumination (zero lux, up to 30m or 50m in enhanced mode). Can be used in wide-angle or telephoto modes. With a massive 2.0MP resolution, you'll not only recognise faces but count the freckles! Note: not a wireless camera (connects to a standard RJ45 ethernet connection with PoE [power over ethernet]) and supports multiple streams up to 10 clients. Yes, it is more expensive than most . . . but if you want the best . . .

$665

want to put the camera, find another location.

(2) Out of reach of intruders or vandals!

You don't want your camera to be put out of action because it can be reached. Even if it sends an alarm when tampered with (some do), a smashed or disconnected camera could still mean you've lost vision (some high end ones may well keep recording to their own memory card).

Also ensure there is nothing left around (a wheelie bin, for example) which might assist as a climbing aid for some cretin with a brick or a pair of cutters! (Put the bricks away, too . . .)

(3) Unobtrusive

If at all possible (and it often isn't), try not to advertise the fact that you have a camera (unless you really *do* want the neighbourhood to know, perhaps as a deterrent). Often, it's best that the first thing an intruder knows about your system is when they hear those magic words, "You're nicked, sunshine!"

(4) Ease of cabling

As we mentioned earlier, even wireless IP cameras need to be powered. Some locations make it difficult, if not impossible, to get cables through. And Murphy's Law will always ensure that the best location is about half-a-metre too far from the power source!

If power is a real problem, consider a solar-panel and battery-powered system. You'll pay more but that might be a good investment.

(5) Not looking into the sun

Apart from the fact that the camera could be "blind" for a good part of the day, direct sunshine into the lens will almost certainly damage the sensor over time (and sometimes a very short time). Remember too that the path of the sun changes over the course of a year!

(6) Consider the legalities

The law regarding the use of a webcam is very much the same as using any camera (still or movie). Setting up a security camera **on your own property** is *generally* quite legal, especially if it is pointing into your own yard, or even out into the street or other public place.

Even setting up a camera on a neighbour's property, *with their permission*, aimed back at your place should be quite OK.

Where you may run foul of the law is if, for example, your camera might be aimed at a neighbour's house (even inadvertently – beware auto pan and tilt cameras!) and records images from their bedroom or bathroom. Then (for example in NSW) you could be in breach of Division 15B of the NSW Crimes Act 1900 (specifically section 91). This follows somewhat similar legislation in Queensland (Section 227A(2)).

You *may* also breach Privacy Legislation where children are involved, even in a public place. However, the restrictions are quite narrow and specific (much more than most people believe).

What about the audio recording?

One other point: if your camera includes a microphone, then any speech recorded could come (in NSW, other states have similar) under section 7(1) of the Surveillance Devices Act 2007 No 64, which prohibits the recording of private

What if you don't have an IP cam?

Within reason, you don't need one . . . that is, if your PC has a built-in camera. And these days, most tablets and laptops do! You can even use a spare Apple or Android phone for the same thing – it's not easy to find a phone in the last decade or so that doesn't have a camera built in!

You can aim the camera in your device in the direction you want to view. Your PC or phone will possibly have come with software loaded to allow you to use it as a webcam; going one step further and getting it on the net is relatively simple.

One caveat: you need to be able to stop your PC or phone "going to sleep"; in some cases, this may not be possible. Read your instruction manual (or make an appointment with Dr Google) to check.

Windows Smartphone/Tablets

If your PC doesn't have webcam software, you can download one of the many freebie webcam packages available on the net. As an example, we're using a Java webcam app called YAWCAM. That, by the way, stands for Yet Another Webcam! It's certainly not a new package (I believe it first came out about 2003; the latest version [0.4.1] is February 2013) but it's simple to use and offers quite a range of features. Your new best friend Google may find one that suits you even better but we'll stick with YAWCAM for the moment.

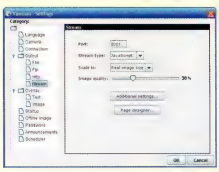
And we'll get to Apple/Android phones shortly.

The 4.5MB YAWCAM download suits all iterations of Windows from 2000, including XP, Vista and Windows 7 & 8. You will also need Java Runtime Environment (JRE) 6 or later, DirectX 9 or later and Windows Media Player 9 or later. Your machine is very likely to have these already; if not or if you need to update, these are all free downloads – for JRE go to **https://java.com/download** and for the Windows software there are numerous sites for download including Microsoft/Windows.

Best of all, as I said before, YAWCAM is free – though the author does ask for a donation to cancer research if you find YAWCAM useful.

Log on to **www.yawcam.com** and select the Download tab from the list on the left side. It's an advert-supported site so clicking on any other download icon could have you marrying some lovely Russian model! Once downloaded, click on and install the app.

You can use any camera in or attached to your web-connected PC then publish the live video via the web. First make sure the camera you want to use is installed correctly with appropriate drivers (if it is an external webcam, these would have been supplied with the camera).



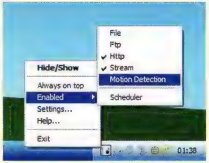
When you launch YAWCAM, it should detect any webcams you have – either internal or external.

Using an Apple (iOS) Smartphone/Tablet

We'll start with an Apple (iOS) device. You'll need to download the appropriate app – for iOS, try the Wireless Camera app from the App Store. It will cost you heaps: $US2.00! It uses the iOS built-in Web Server function to start a website on your local network.

One of the beauties of an IP cam is that you can be on the other side of the world (as long as you have 'net access) – this one's in Sweden.

Download, install and then open Wireless Camera. The default "Interval" and "Maximum Images" settings should be fine but you can tweak them if you wish. All that's left is to make sure "Motion Detection", "Add Timestamp" and "Enabled" are all checked and your webcam will start sending what it sees.



This can be viewed on any browser in your local network by pointing it to the local IP address, which the app will give you when you start streaming.

Viewing from anywhere else (ie, a remote browser) is a little more complicated; the router's "Network Address Translation" and "Port Forwarding" features need to be set up to ensure than any incoming request is directed towards the iOS phone. You'll need to access the router's set-up to do this; refer to the instructions that came with your router.

Using an Android

A different app is required for Android devices. We like Motion Detector Pro, a 766kB download available from Google Play (simply search for the name). As its description says, this app enables you to use your Android device as a remote surveillance camera or spy cam with motion detection functionality.

The latest version (1.2.2) enables frontface camera support so you can use either camera if two are fitted.

Again, there are many other apps to do the same or similar things – some offer many more features but this can be at the expense of either memory or space. Still, if that's all you're doing with the (surplus) phone, that's no big deal.

conversations without consent.

Presumably, that even includes two crooks talking to each other in *your* backyard – while the video from your webcam is quite OK!

While all this might be a grey area, that could change in the future (the world is definitely getting more paranoid). A word to the wise: use the webcam for the purpose for which it was intended!

Setting it up

OK, you've gone ahead and purchased one (or more) wireless IP security cameras which look like they'll suit your purposes. You've also chosen the camera location and worked out how to get the power cabling to it.

Before you mount the camera, we strongly suggest you get it going at ground level first. As the old proverb says, "there's many a slip between cup and lip".

Invariably, every wireless IP camera instruction sheet we've seen says to set it up using a network (Cat5e) cable before moving on to wireless. That's good advice because it takes one variable out of the equation.

Then, when it all works, flip over to wireless and prove that's a goer too. That's not without its pitfalls which is why we've prepared a separate "Going Wireles" article elsewhere in this issue.

And before you start, read right through the instructions packaged with the camera, even if they're in Chinglish, so you have at least a reasonable understanding of what's required. In the vast majority of cases, manufacturers give a website for additional information (though we're not saying that's always kosher, either!).

As we mentioned earlier, if in doubt AND you purchased over-the-counter, ask your supplier.

Example: EasyN Camera Setup

Apart from the hassles of translating an instruction sheet to English, (and the uber-tiny print on an A6 page!) EasyN is simple to set up once you get the bugs out. In fact, it is one of the easiest we tried because once you find the right software, it's all virtually automatic:

1: plug the network cable into your modem/router.
2: connect the power supply
3: download the software from your iPhone/Android store (it's free),
4: use your smartphone's camera and QR code software to take a pic of the camera's QR code (barcode) on your phone. This "fills in all the blanks" so your phone can log onto the right camera.

And that's pretty much it. Of course, it helps if your phone has that QR code software (mine didn't, so I had to download that too – it's free) but once loaded, it accepted the image of the barcode without any problem.

The smartphone image (as seen on page 16) came up pretty well straight away and I was able to move the pan/tilt EasyN camera by swiping the screen.

Oh, one slight difficulty – on loading, the pan/tilt worked opposite to that shown; ie, you swiped up to go down, left to go right, etc. It was only then that I realised I had the camera sitting on a shelf, so it was effectively upside down!

Wireless camera setup

Overleaf, we look at how to set up IP cameras using wireless connections. It's not that difficult – but there are some traps for the unwary. SC

Radio, Television & Hobbies: the COMPLETE archive on DVD

This remarkable collection of PDFs ***covers every issue*** of R & H, as it was known from the beginning (April 1939 – price sixpence!) right through to the final edition of R, TV & H in March 1965, before it disappeared forever with the change of name to EA.

For the first time ever, complete and in one handy DVD, every article and every issue is covered.

If you're an old timer (or even young timer!) into vintage radio, it doesn't get much more vintage than this. If you're a student of history, this archive gives an extraordinary insight into the amazing breakthroughs made in radio and electronics technology following the war years.

And speaking of the war years, R & H had some of the best propaganda imaginable! Even if you're just an electronics dabbler, there's something here to interest you.

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"IP": What does that mean?

We've talked about "IP" cameras this month – but do you know what those two letters means? In electronics/computing, they commonly have two meanings – and when referring to security cameras, both are important, especially those to be used outside!

(1) Internet Protocol

This simply means that it is a device which can be used on and accessed via the internet, because it conforms to the standards used by the internet.

The Internet Protocol is part of TCP/IP (Transmission Control Protocol/Internet Protocol) and the terms "IP network" and "TCP/IP" are basically synonymous.

IP uses a "packet switched" architecture, in which data are broken up into many smaller "packets", each one also containing a source address and a destination address.

This means the packet is routable – that is, any terminal or node which receives the packet will forward it along until it reaches its destination.

The other important point to note is that a temporary loss of data signal will normally mean that most packets will get through. TCP also ensures that missing or corrupted packets are normally re-sent, with error checking built in.

The data packets may not arrive in the same order, nor perhaps even via the same route, but are "re-assembled" at the receiving end.

As well as being the communications protocol of the public internet, Internet Protocol is also used by many Wide Area Networks (WANs) and most Local Area Networks (LANs).

(2) Ingress Protection rating

This is an internationally recognised standard, devised by the IEC (International Electrotechnical Commission), and defines just what – both solids and liquids – can or cannot enter a particular device.

The device in question will have a code consisting of the letters IP followed by two digits – for example, **IP65**.

The first digit, from 0 to 6, refers to protection against solid particle ingress while the second, from 0 to 8, refers to ingress of liquids (usually, specifically, water).

The table below shows IP ratings and their meanings. As you can see, the higher the numbers, the better the protection.

A device for use inside might have a rating of, say, IP43 – it's protected against most small objects greater than 1mm in size and can withstand spraying water for five minutes.

For outside use, the minimum you would expect is IP65 or IP66 – dust tight and reasonably high pressure water resistant for at least three minutes.

Higher ratings (IP67 or IP68) can stand full immersion in water up to 1m (or more).

INGRESS PROTECTION RATING

First Digit: Object Size Protected Against		Effective against
0	—	No protection against contact and ingress of objects
1	>50mm	Any large body, such as the back of a hand, but no protection against deliberate contact with a body part
2	>12.5mm	Fingers or similar objects
3	>2.5mm	Tools, thick wires, etc.
4	>1mm	Most wires, screws, etc.
5	Dust protected	Ingress of dust is not entirely prevented but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment; complete protection against contact
6	Dust tight	No ingress of dust; complete protection against contact

Second Digit: Level Protected against		Testing for
0	Not protected	—
1	Dripping water	Dripping water (vertically falling drops) shall have no harmful effect. *Test duration: 10 minutes, Water equivalent to 1mm rainfall per minute*
2	Dripping water	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle of up to 15° from its normal position. *Test duration: 10 minutes Water equivalent to 3mm rainfall per minute*
3	Spraying water	Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect. *Test duration: 5 minutes. Water volume: 0.7 litres per minute. Pressure: 80–100kPa*
4	Splashing of water	Water splashing against the enclosure from any direction shall have no harmful effect. *Test duration: 5 minutes. Water volume: 10 litres per minute. Pressure: 80–100kPa*
5	Water jets	Water projected by a nozzle (6.3mm) against enclosure from any direction shall have no harmful effects. *Test duration: at least 3 minutes. Water volume: 12.5 litres per minute. Pressure: 30kPa at distance of 3 m*
6	Powerful waterjets	Water projected in powerful jets (12.5mm nozzle) against the enclosure from any direction shall have no harmful effects. *Test duration: at least 3 minutes. Water volume: 100 litres per minute. Pressure: 100kPa at distance of 3 m*
7	Immersion up to 1m	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1m of submersion). *Test duration: 30 minutes. Immersion at depth of at least 1m measured at bottom of device, and at least 150mm measured at top of device*
8	Immersion beyond 1m	The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects. SC

Setting Up An IP Camera For WiFi & Internet Access

By Nicholas Vinen & Greg Swain

Setting up an IP camera for WiFi is usually pretty straightforward. Often, it's just a matter of plugging it into a router via a Cat5 cable, figuring out its IP address, then logging into the camera's web interface and entering the details for your WiFi network (SSID & password). It's not always plain sailing though, especially if you want to access your camera on a PC, tablet or smartphone via the internet.

AS STATED in our feature article this month on IP cameras, it's invariably necessary to set up a camera using a wired (Cat5) connection before it can be used on a wireless network. That's because certain information is required for the camera to be able to "join" your wireless network and accessing the camera via a cable allows you to enter this information.

Wireless networks are identified by their "SSID" name so you'll need to know the name of your network. If in doubt, check the settings of a device already connected to it, eg, a smartphone. There will almost always be an accompanying password required to gain access to your WiFi network. The security protocol should be either WPA or WPA2 but you can only choose the latter if all other WiFi devices on the network support it.

Once you have these details, it's just a matter of logging into the camera's web interface and entering the necessary details to enable it to join the WiFi network. That's typically done by typing its IP address into a web browser and going to the relevant set-up menu. After that, you can unplug the Cat5 cable and continue to access the camera over the wireless network.

By the way, if you don't have a password for your WiFi network, set one up now! An open network is an invitation to get viruses, have your personal files accessed or have random strangers use your internet connection (possibly for illegal purposes!).

What's the camera's IP?

The first step in the setting-up procedure is to connect the camera to a spare port on your router. Assuming that your router has DHCP enabled (usually the default setting), it will automatically allocate an IP address to the camera (just as it does for other devices on the network, such as PCs, laptops and smartphones).

For the uninitiated, an IP address is a unique set of numbers allocated to each device on your private network to identify it. It usually contains four

numbers separated by dots, starting with either "192.168." (eg, 192.168.0.5) or "10." (eg, 10.0.0.1). Each device on your network ends in a different number, so that each device has its own unique number.

There's one small detail though – how do you know which IP address has been "handed out" to the camera, so that you can log into and set it up for WiFi and to change other settings? Basically, you need to figure out which address the camera has been allocated and if you have multiple cameras, they will have different addresses.

By default, the addresses are allocated by your modem/router to ensure there are no "collisions" (ie, devices with the same address). It will also often be configured to "hand out" addresses in a specific range. For example, if the router itself has an internal IP address of 192.168.1.1, then it may be configured to hand out IP addresses in the range from 192.168.1.2 to 192.168.1.20.

Some cameras, such as the TechView QC-3834 (and the QC-3832) are supplied with utility software which will tell you their IP address once you've connected them to your network. If so, use this as it's probably the easiest method.

In the case of the TechView cameras, this utility is called "IP Camera Tool". It's simply a matter of installing it on your PC and running it. The utility will then show the camera's IP and its port number. If there is more than one TechView camera on the network, it too will be listed.

Fig.1 shows a typical example. In this case, a camera has been detected on 192.168.1.5 and port 80. Double-clicking on the listing will then bring up the camera's web interface and you can then log into it by entering in the user name and password (the default user name is usually "admin", while the default password is usually just left blank or can also be "admin").

Typically, an IP camera will have a default port number of 80 or 81. Note that each camera must have a unique port number, so if you are setting up two or more cameras be sure to change the port numbers to avoid conflicts (eg, to 8888, 8080, etc).

Making a guess

Another method of determining the camera's IP is to simply make an educated guess. That's done by first checking the address allocated to your PC or phone. For example, in Windows you can determine your PC's IP address by pressing the Windows Key + R, typing "cmd" and pressing Enter, then typing "ipconfig" and pressing Enter. The display will be similar to that shown in Fig.2.

Here we can see that the computer's IP address is 192.168.1.2 and this has been allocated by the router (also acting as the Default Gateway) which is at 192.168.1.1. The camera might therefore be 192.168.1.3 or 192.168.1.4 or something similar – unless these addresses have already been used by other devices such as smartphones or smart TVs.

Anyway, chances are that the number allocated to the camera will not be too different from that of your PC so it should not take long to find. To test an address, type both it and the camera's port number (the two separated by a colon) into the address bar of a web browser. If it's the right one, the camera's web interface will quickly come up.

How do you know the port number? Well, the camera will be allocated a default number and this will be listed in the instructions supplied with the camera or printed on the camera body. For example, if the default port number is 80 and you want to test an IP address of 192.168.0.7, it's just a matter of typing 192.168.0.7:80 into your browser's address bar and pressing Enter.

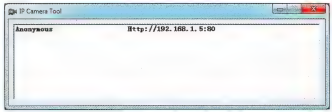

Fig.1: TechView's "IP Camera Tool" app shows the camera's IP and port number. You can then log into the camera by double-clicking the listing.

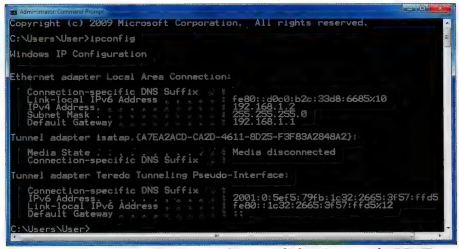

Fig.2: typing "ipconfig" in the Command Prompt dialog gives you the PC's IP address (in this case 192.168.1.2) and the router's IP (192.168.1.1). You can then make an educated guess as to what your camera's IP might be after allowing for other devices (eg, smartphones) on the network.

Get it from the router

Yet another method for determining the camera's IP is to login to your router's web management interface

The EasyN S9014 720p scanning camera from Altronics has its own set-up utility but can also be configured as described in the article. Its default port is 81.

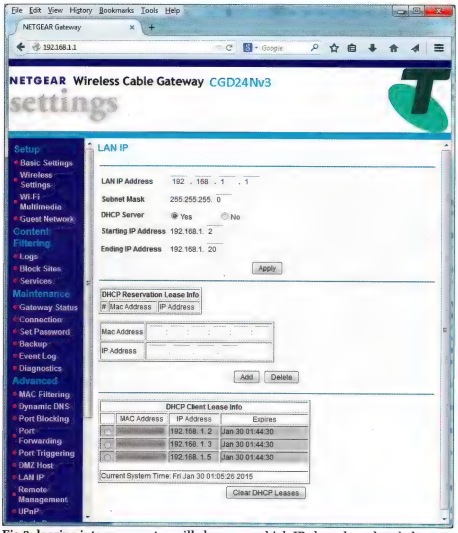

Fig.3: logging into your router will show you which IPs have been handed out to devices on the network. If you've just installed your camera, it will probably be the last one in the list (some routers even list the device name).

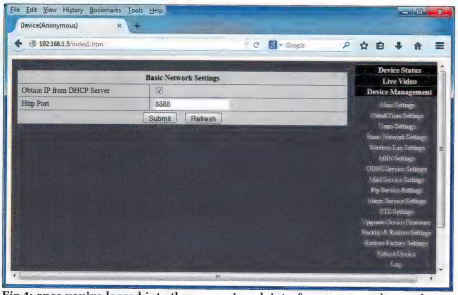

Fig.4: once you've logged into the camera's web interface, you can change the port number if necessary (eg, to 8888) to prevent conflicts with other cameras.

(assuming you know the login details). You should then be able to find a page called "Attached Devices" or "DHCP Client Table" or "LAN IP" or similar (typically somewhere under the Status or Advanced menu). This will list the IP address and possibly the name of each device on your network.

It's then just a matter of finding the camera's listing. If you just set it up, it will probably be at the bottom of the list – see Fig.3.

Many IP cameras come with a DDNS hostname (see text) on a label attached to the base. This lets you access the camera via the internet without having to know your public IP. Once set-up as in Fig.7, you just type the address into a browser and substitute the camera's port number for "xxx".

Getting the WiFi working

Once you've determined the correct IP, you can then use this interface to get the camera on the WiFi network. Note that it will be assigned a different IP address on the wireless network than the one allocated on the wired network, so once you unplug the fixed cable, you will have to figure out its new wireless IP (using the same procedure as before). If you can then access its web interface with the Cat5 cable unplugged, you know it has successfully joined your wireless network.

If you're sure that you've correctly entered the WiFi settings into your camera (and rebooted it, if necessary) but you still can't access it via the wireless network, you may have a security feature called "MAC Address Filtering" enabled in your router. You will have to log into its web interface and either disable this feature or add the camera's unique MAC (Media Access Control) address to the list of allowed addresses.

Most routers make adding a MAC to the list quite easy; once you've found the right menu and chosen to add a new address, it will normally give you a list of discovered devices to add, possibly with names alongside. It's then just a matter of choosing the right one (ie, your camera's MAC), adding it and saving the changes.

You may also find the MAC address printed on the camera. If so, it will be in the form of six pairs of letters/num-

bers separated by colons or dashes. For example, "12-34-56-78-9A-BC".

Security

Before going any further, make sure you have set your own user name and access password for the camera via its web interface. And don't make it too easy – "password" and "12345" are terrible passwords, as are single dictionary words or a person's first name. These are the first things any potential hacker would try if they want to access your camera.

It's especially critical to set a good password for indoor cameras, unless you like the idea of strangers watching you! There are internet databases of many thousands of unsecured webcams which can be found with a simple web search – don't find yourself among them. If you can change the user name, you should do that too as it makes it that much harder for someone to guess the login details.

Once you have everything set up, you can view the camera's video on the local network simply by entering its IP address and port number into your browser and logging on. Of course, if the router is switched off, then it might allocate a different IP to the camera when it is switched back on again. The same applies if the camera is switched off and on again.

One way around this is to allocate a static IP address to the camera but make sure that this is outside the router's DHCP range. However, there are other methods which don't require a static IP, as we shall see later.

Viewing via the internet

In most cases, a WiFi camera will come with a unique DDNS hostname to enable you to view it from a remote location. DDNS stands for "Dynamic Domain Name Server" and it allows you to log on to your home network without knowing your home network's public (or WAN) IP.

It can be as simple as setting the camera up, as described above, then typing in the website address printed on the bottom of the camera (or scanning a barcode which takes you straight to that address) and away you go. As before, you have to include the port number at the end of this address.

If it works, then your modem/router has automatic port forwarding (more on this shortly) and you don't have to do anything else. In some cases though,

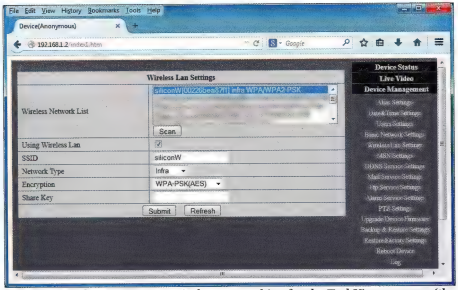

Fig.5: here's where you set up wireless networking for the TechView cameras (the interface for the EasyN cameras is similar). It's just a matter of adding the SSID (network name), encryption protocol & password (share key).

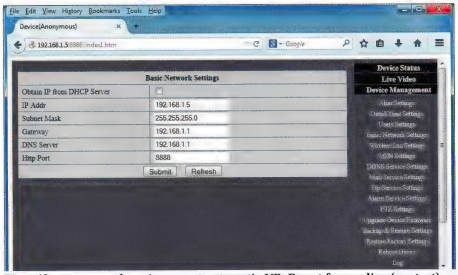

Fig.6: if your router doesn't support automatic UPnP port forwarding (see text), then it may be necessary to manually assign a static IP to each camera so that you can manually enter the port forwarding details into the router (see Fig.9).

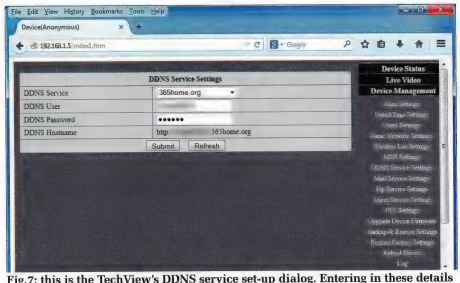

Fig.7: this is the TechView's DDNS service set-up dialog. Entering in these details lets you log-in to the camera via the internet without knowing your public IP.

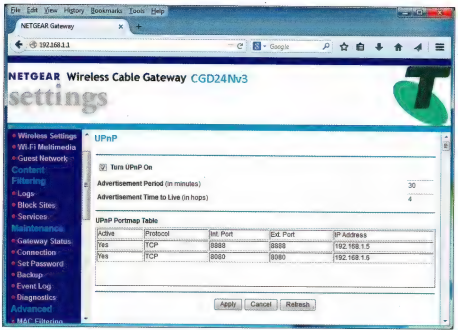

Fig.8: if your router supports UPnP port forwarding, make sure it's enabled if you want to access the camera via the internet. The router will then automatically port forward any UPnP devices (such as IP cameras).

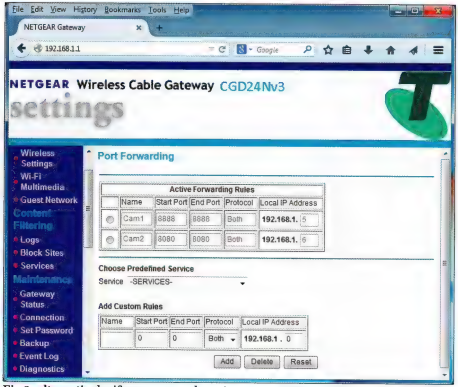

Fig.9: alternatively, if your router doesn't support UPnP port forwarding, it will be necessary to manually add port forwarding for each device. Here, two IPs have been port forwarded: 192.168.1.5 on port 8888 and 192.168.6 on port 8080.

you will need to manually set up the port forwarding on your modem/router to allow you to make a connection from the public internet to your camera which is on your private network.

Basically, a software "firewall" is built into the modem/router, designed to prevent worms, viruses and hackers from accessing your PC or other equipment on your network. In order to make a connection to the camera, you have to open up the relevant "port" in this firewall so that data can pass through. We'll look at this shortly but first, let's take a look at dynamic DNS.

Dynamic DNS

If your camera does not offer an easy way to connect remotely, the first thing you will need to do is figure out your public internet IP (or WAN) address as this will be required to make a connection from another location. It's akin to your home address (basically, it's your address on the internet) and as with a private IP address, it's typically four numbers separated by dots.

How do you determine your public IP adddress? Easy – just type *what is my ip* into the Google search engine and press Enter.

Once you have your IP, try typing it into a web browser followed by a colon and then the camera's port number. Provided port forwarding has been set up correctly (see later), you should be able to log onto the camera.

Unfortunately, in many cases, your WAN IP isn't a fixed address. Provided you leave the router on, it may stay the same for days, weeks or even months but unless you have been allocated a static IP address by your internet service provider, power cycling your modem may well result in it obtaining a new address. And if that happens while you're away (eg, due to a power failure) you will then be unable to view your camera feeds.

The first step here is to determine whether or not you have a static IP. You may need to ask your internet service provider (ISP) to find out. Alternatively, a quick Google search will confirm whether they offer this service and whether it's an extra-cost option. In some cases, you may get a static IP if you're on a long-term contract.

If it turns out you do have a static IP, then you're in business. Otherwise, you will probably need to set up DDNS (Dynamic DNS) yourself. This is a scheme whereby your computer or router contacts a fixed server on the internet each time your IP address changes and informs it of the new address. This static server can then send you to the right place.

Just about all routers have support for DDNS built-in. If yours doesn't, you will need to leave a PC or laptop powered on and active at all times in order to provide this service. However, a better solution is to upgrade to a router which does have DDNS support – it will almost certainly consume less power for a start.

You will also need to sign up for a DDNS provider. There are several free ones such as **www.noip.com/free** and **www.dynamicdns.org** Once you

have signed up via their website, the DDNS provider will then give you an address such as myip.noip.com or myip.dynamicdns.org (where "myip" is a name you have chosen) and you then use this to connect to your home network from anywhere in the world. Note, however, that you also need to program the DDNS log-in information into your DDNS client (ie, via the router's web interface) for this to work.

UPnP & Port forwarding

Now that you have your home IP or DDNS address, try accessing your camera by typing that address into a web browser, followed by a colon and then the camera's port number. If it works, then your router has inbuilt support for automatic port forwarding via UPnP (Universal Plug and Play) and that's the end of the story. Of course, your WiFi camera must have inbuilt UPnP support but most do.

If it doesn't work, log in to your router's web interface and check to see if it has a set-up menu for UPnP. If it does, it might be disabled. If so, enable it and try connecting to your camera again.

Unfortunately, that not all routers with UPnP support automatic port forwarding, so it may still not work even after UPnP has been enabled. And if your camera doesn't support UPnP, then it won't work in any case. Either way, you will have to manually set up port forwarding on the router in order to gain remote access via the internet.

In greater detail, "ports" are part of the Internet Protocol, along with the IP addresses mentioned earlier. Each IP address has 65,536 different port numbers associated with it. This allows a given computer on the internet to host many different services such as web (HTTP), file transfer (FTP), chat, camera streams and so on.

By the way, when you have a home router with multiple computers on the home network, these ports are also used as a way to share your single public IP address among the various computers. Each connection made from a computer on your private network to the internet is associated with a specific port, so that when the router gets a response it knows which computer or device on the LAN (local area network, ie, private network) it is intended for. This is known as "Network Address Translation" or NAT.

Similarly, the router needs to know

Alarm, Email & FTP Services

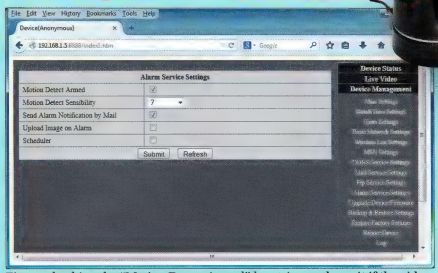

Fig.10: checking the "Motion Detect Armed" box triggers the unit if the video image suddenly changes (eg, if there's an intruder). You can also set the alarm sensitivity and send alarm notifications (with pictures) by email.

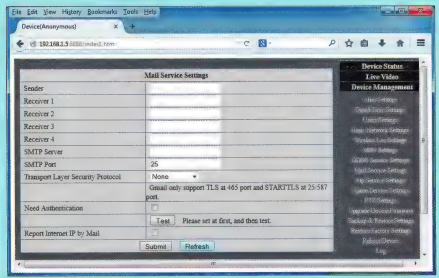

Fig.11: the TechView camera's Mail Service Settings dialog. The "Sender" is usually your current email address and the unit can email up to four recipients if the alarm is triggered.

Apart from their basic video functions, many WiFi cameras (including the TechView QC-3834 and the EasyN S9014) also feature an alarm function plus in-built email and FTP servers.

The alarm function on the TechView QC-3834 is activated using the menu dialog shown in Fig.10. Its just a matter of "ticking" the Alarm box and selecting the sensitivity level. The unit will then trigger whenever it detects a rapid change in the video image.

Provided you've also entered your email details into the menu dialog shown in Fig.11, the unit will then send an email to warn you that the alarm has triggered. It will also send several (usually up to six) photographs, so that you can see what it was that triggered the alarm. You can also set the unit up to upload an image to an FTP site and even set up scheduling for the alarm (eg, to prevent it triggering during office hours on weekdays).

Another feature of both the TechView QC-3834 and the EasyN S9014 units is a 4-pin I/O connector for an external alarm. Two of these pins are used as an input pair for an external sensor (eg, a PIR sensor), while the other two pins are the output pair (eg, to trigger a house alarm or an external powered siren).

Want to monitor your camera using a smartphone? – just install the relevant app. The photo at right shows TechView's "IP Cam" running on an iPhone 5 while the photo above shows the set-up dialog.

which device a connection should be routed to when you connect to your public IP on the camera-specific port. This is especially important if you have two or more cameras; they must be assigned different port numbers, otherwise the router will not know which camera you are trying to view from your remote location.

Manual port forwarding

Just how you go about setting up port forwarding depends on the router you're using.

Most routers only do port forwarding to a specific LAN IP address rather than a specific device. As mentioned earlier, by default, LAN IP addresses are handed out by the router using DHCP (Dynamic Host Configuration Protocol). The key word here is "dynamic" – it's liable to change over time. Again, this commonly happens when there's a power outage but a DHCP-assigned address may change for other reasons, too.

If you have this type of router, you'll have to assign each camera a static (ie, fixed) internal address. You will then need to set up the port forwarding entry to the camera's new fixed IP address.

There are two ways to assign a fixed IP address to a device and again it depends on your router. If your router has the ability to assign fixed IP addresses using DHCP then this is the best method. This may be listed under a heading such as "DHCP Reserved Addresses", probably under a menu titled "LAN Settings".

Assuming your router has it and you've found it, enter the camera's MAC address and its current IP address (which may already be filled in for you), then save the change. Its address will always be the same from then on.

Fig.9 shows the port forwarding set-up for two cameras on a Netgear WND3700 router. The external port number should be between 1024 and 65535 and as stated earlier, 8080 or 8888 are commonly used. Or you could use say 8000 for one camera, 8001 for another etc. Note that the start and end port numbers should be the same, since each camera device only uses a single port.

On the other hand, some routers allow you to only forward a specific external port number to one device on your LAN as determined by its DHCP-provided name (ie, the name in the list of attached devices). If that's the case, all you need to do is find the router's port forwarding settings page, then set up a port forward from a number of your choosing which is associated with the camera device, selected from the list of attached devices.

IP address/port pairs

There's one further wrinkle here – some modem/routers let you set up IP address/port pairs. To forward a port, two IP address/port pairs are required – the original address/port and the forwarded destination address/port.

In this case, the original address is your public internet address which the router already knows, so you only need to provide the port for the router to "listen" on for its public address (ie, the "external port"), the IP address to forward the connections to (ie, the camera's address) and the camera port to which the connection should be routed (ie, the "internal port").

Once the port forwarding settings have been saved, you should then be able to connect from a remote location by entering your public IP address and the camera's port number into a web browser. Alternatively, you should be able to connect by entering in the DDNS hostname printed on the bottom of the camera.

No dice?

What if your router is unable to assign a static IP to a device based on its MAC number? In that case, you will need to use the camera's web interface to assign it a fixed IP address outside the range of addresses your DHCP server is configured to hand out. This is important since otherwise, you could easily end up with an address collision, rendering both the camera and the other device temporarily unusable.

This isn't too hard to do. First, via the router's web interface, determine the range of addresses it is configured to supply for DHCP. This will normally be found in the "Basic Setup" or "LAN Settings" menu, under a heading titled "Network Address Server Settings (DHCP)" or similar. For example, the router may be configured to hand out IP addresses ranging from 192.168.1.2 to 192.168.1.20.

In this case, any static address you assign to the camera should be no lower than 192.168.1.21. The last number in the address can go as high as 254, eg, 192.168.1.200 would be OK but 192.168.1.255 is invalid. Be sure to use a unique IP for each device.

Once you've assigned this address to the camera and checked that you can access it locally, set up the router's port forwarding to go to this new IP address. As before, make sure you pick a unique (and memorable) external port and that the internal port is set to that which is required by the specific camera. SC

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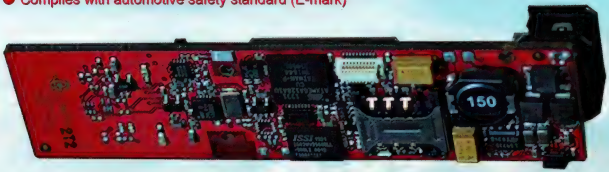
- Portable or externally connectable to integrate multiple sensors
- On-board sensors for compass, temperature and acceleration
- Worldwide coverage: Quad-band GSM/GPRS • Glonass/GPS • Wifi
- Complies with additional standards for insurance benefits (e.g. SCM and Incert)
- Complies with automotive safety standard (E-mark)



We would like to invite you to have a look around our website and get inspired by the possibilities of what KCS TraceME products can bring to your project. Whether you need a solution for personal tracking, trace and control vehicles, object protection or more advanced M2M solutions, KCS TraceME can deliver it.

GPS/GPRS enabled GPS Tracker with advanced I/O. This will allow you to remotely track & trace and/or control a huge diversity of objects, machines and/or vehicles. KCS TraceME is absolutely the most versatile and adaptive Track-n-Trace solution in the market today. Our clients use the TraceME hardware for the most diverse tasks. It is truly an all-round performer and exceeds anything in the market currently available.

- KCS TraceME is available in different form factors (Key fob, OEM, Aluminum & custom made casing);
- GPRS, UMTS, SMS, GSM, Wi-FI, RFID, E-mail;
- Fully configurable administration tool;
- Event driven, can run custom code, remotely configurable;
- Connect M2M to any device;
- G-shock detection, temperatures, tilt, motion, iButtons, mobile phones, camera's;
- See the rest of the site for the full options!

Please contact us if you want to discuss your ideas!

OEM & Distributor requests are welcome!

www.Trace.ME

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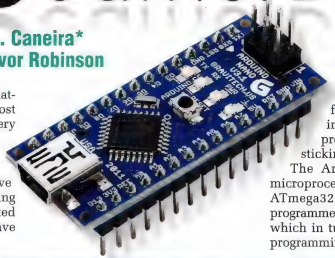
A professional quality Weather Station based on ARDUINO

Pro2 wireless weather station WeatherDuino

Part 1

System designed by A. Caneira*
Built and written by Trevor Robinson

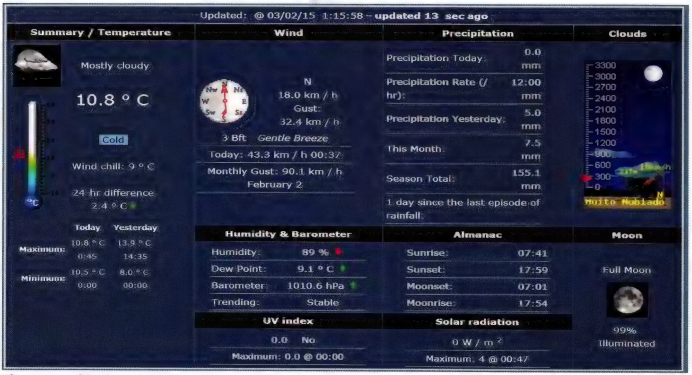


Based on the Arduino Nano platform (see right), this low-cost weather station system is very flexible, with many options.

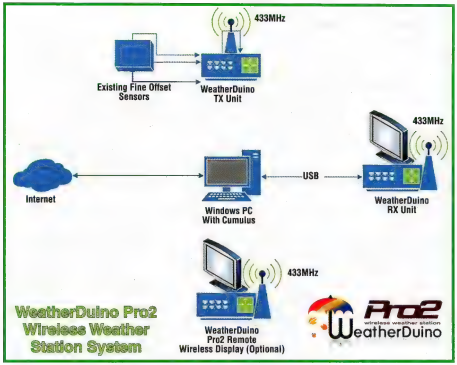
To construct this system you will need some basic electronic and computing experience. If you have built and programmed projects using the Arduino platform and associated electronics, then you shouldn't have any trouble building this one!

It can use quite a few different sensor types, though in an attempt to simplify the project somewhat, we'll be sticking to only a few.

The Arduino Nano is a small microprocessor board based on the ATmega328 chip that comes pre-programmed with a special bootloader which in turn allows easier end use programming via USB and the Ar-



There's a wealth of weather information available – everything from temperature and humidity to rainfall and windspeed.



duino IDE (integrated development environment).

It comes with 32KB flash memory though 2KB is used by the bootloader. Its clock speed is 16MHz and its recommended supply voltage is 7-12VDC.

Overview

This system can be built in a few different configurations using the following modules.

TX Unit (Transmitter Unit). Gathers and processes data from the sensors then transmits this data as packets at different time intervals (for example, wind data is sent every five seconds). Construction and configuration will be covered in Part 2.

RX Unit (Receiver Unit). Receives the data from the TX unit and displays the data on either a 20x4 character LCD or 1.8" 160x128 TFT display. You can even run multiple RX units off one weather sensor suite. The RX unit can transmit to the Wireless Display unit (described next). It also displays the temperature and humidity of where it is located. Construction and configuration will be covered in Part 3.

WD Unit (Wireless Display Unit).

A completed Receive Unit (RX unit) in a nice case. The heart of the system is the Arduino Nano shown opposite.

Main features of WeatherDuino

- It uses affordable parts.
- Uses the commonly available and affordable "Fine Offset" sensors; Anemometer, Wind vane and Rain gauge. The system also allows the sensors to be moved away from each other to better locations.
- Has the accuracy of a high-end weather station by utilising DHT/SHT temperature and humidity sensors.
- Can measure and report solar radiation and UV levels with optional board.
- Connects to a Windows computer running Cumulus software. This excellent software also allows the unloading of data to your own Weather web site and online services such as WeatherUnderground. Support for a cross platform (Windows, Mac, Linux/Raspberry Pi) operating systems is currently in beta testing.
- Can run multiple wireless display units that can show the outside data along with the current location temperature.
- The outside weather data transmitter (TX Unit) can be run from a solar cell-charged battery.
- Communicates over 433MHz with better reliability and data integrity than the donor weather station.
- Range can be up to 100m depending on the antenna used and environment.
- Can use either an affordable LCD or TFT Display on the receiver unit (RX Unit).
- All modules synchronise time from the host computer.

* www.meteocercal.info/forum/

At left is a receiver board fitted to a wall or desk display case. Above (top) is an assembled transmitter (TX) board. This gathers data from each of the sensors and transmits it to the receiver (RX) board, which is shown lower right. This is the latest V4.02 board.

Displays received data from the RX unit on either a 20x4 character LCD or 2.4" 320x240 or 1.8" 160x128 TFT display.

With its own temperature/humidity sensor, it too can display the temperature and humidity of where it is located. You can have multiple WDU's spread around the home or office, as long as they are in range of the RX unit signal.

Construction and configuration of this will be covered in Part 4.

Solar Radiation Sensor. Interfaces to the TX Unit to supply UV and radiation data. At the time of writing, a standardised setup and procedure is being developed. Currently it's a bespoke solution due to variations in the solar cells used. For more information on this, it would pay to read up on it at the Meteocercal forum (www.meteocercal.info/forum/).

System modules diagram

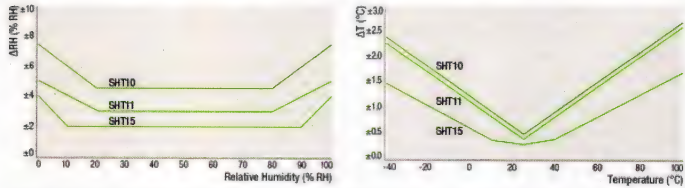
The TX, RX and Wireless display units communicate using 433MHz license-free modules. The TX unit sends the weather data packets to the RX unit, which processes this data and sends it to the PC running Cumulus, via USB using the Davis Pro2/Vue protocol.

If you install the few, and optional, extra data relay components, the RX unit actually becomes a transceiver and can relay data to the optional Wireless Display unit. If you wish, you can build and use more than one Wireless Display unit.

At the conclusion of this series of articles, you will have a fully-featured weather station.

You will also have a Wireless Display Unit that you can put anywhere around the home or office to view the current weather data.

If you install the recommended free Cumulus software (please donate to the developer if you do), this weather station's data will also be able to be viewed on the host computer screen and if desired, uploaded to a website to view anywhere, via Twitter,



These graphs show the comparitive accuracy of the Sensirion SHT1x series. To keep the project simple, we are going with the SHT10, which we think is the best mix of value versus accuracy. If you want higher accuracy, you'll pay more!

WeatherUnderground and a few other on-line services.

The Sensors

Now let's turn our attention to the sensors that connect to the WeatherDuino Pro 2 TX Unit and how they work.

The system is designed to use the "Fine Offset" sensor suite. These can found on auction sites etc. Fine Offset weather stations (and their sensors) are often rebadged under a lot of different brand names, ie, Digitech, Holman and a lot more.

If the sensors look like those at right then they are very likely to work. LaCrosse sensors should too, though they're untested at the time of writing.

Additionally, the system is also compatible with the RF rain gauges and anemometers from weather stations like Auriol H13726, Ventus W155 and other clones, though these seem to be uncommon in Australia.

The Anemometer: This sensor measures wind speed. It is a simple device that uses a reed switch and magnet to measure rotation speed. The Arduino counts the pulses to work out the speed.

The Wind Vane: This measures wind direction. It too uses a magnet and reed switches (usually eight or sixteen) to switch in various value resistors, depending on which reed switch the magnet (attached to the vane shaft) is closest to. The Arduino reads the resistance and from this works out where the vane is pointing.

The Rain Gauge: Once again, this use s a reed switch and a magnet. The magnet is connected to a mechanism that operates like a seesaw. Once one side gets the amount of water (rain) required (usually measures 0.1mm received in the gauge's mouth) it tips, moving the magnet past the reed switch and draining the water away. Then it repeats this process filling the other side of the seesaw. The Arduino counts the created pulse(s).

Temperature/Humidity: The recommended sensor for outside temperature / humidity readings is the Sensirion SHT1x (SHT10, SHT11 or SHT15) but the cheaper DHT22 is also supported (not recommended for places with constant high humidity).

Barometer: Either the BMP180 or the older BMP085 are supported. The voltage jumper needs to be changed to support one or the other, depending on what pins are used. More on this in Part 3.

The optional Solar Sensor: This sensor is based on a solar cell, that is put to work in its short circuit mode, where its current is proportional to solar radiation.

Of course, doing any modifications to the code cannot be supported by the developer or SILICON CHIP magazine.

The code is compiled and uploaded to the Arduino Nano microprocessor via a USB connection, using the freely-available Arduino IDE (integrated development environment).

You will need the Arduino 1.5.8 BETA IDE as the code requires the extra optimisation that this beta release of the IDE gives, otherwise the code will not fit in the Nano's 32KB flash memory.

Choosing a temperature sensor

Like most things in life, the more you pay, (usually!) the better they are.

This is also true for temperature sensors. Here it's a trade off-of price vs accuracy.

For outside temperature we usually have a better sensor for this location, one that reads more accurately across the expected temperature and humidity range. We can get away with a cheaper sensor for inside due to the smaller range of temperature and humidity.

So do some research and figure out what temperature and pressure sensors you want to go with. Mind you it's easy to swap these out later if you wanted to upgrade them.

To keep the project somewhat simple we are going to assume the SHT10, as we believe it's the best mix of value versus accuracy.

By using multiple TX units, you can mount one or more of the sensors elsewhere. This is handy, for example, if your anemometer needs to be higher than the cable allows, or when you need to move the temperature sensor to a better or shadier position.

As you will see as we continue through this series of articles, the WeatherDuino Pro2 has the ability to be a complete system in its own right. If you are technically minded and know Arduino programming, you can even add your own extra features as the firmware is open-source and can be modified.

Data update rates and packet information

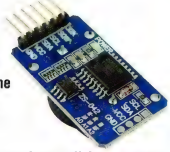
Wind Data Packet	– Sent every 5 seconds. Contains data including Wind Gust, Wind Speed and Wind Direction
Wind Speed	– Value is a rolling average of the last 5 minutes, sampled every 30 seconds
Rain Data Packet	– Sent every 31 seconds
Temperature/Humidity Data Packet	– Sent every 19 seconds
Solar Radiation/UV Index Data Packet	– Sent every 37 seconds
Solar Radiation and UV Index	– Values are a rolling average of the last 2.5 minutes, sampled every 37 seconds
System Info Data Packet	– Sent every 97 seconds. Contains data about system battery or power supply voltage, case temperature (from TMP36 sensor if installed on TX board) and fan state

You can download the Arduino IDE from http://arduino.cc/en/Main/Software Select and downloading the Windows Installer option from the above link.

We will talk further about the code configuration and how to upload it to the Nano later in part 2 when we need it.

Sourcing the parts

If this project perks your interest and you'd like to construct it, it may be a good idea to start to organise the collection and purchase of the items required to do so now.



DS3231 Real Time Clock module

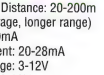
Full parts lists will be presented next month. Many components are over-the-counter items from retailers such as Jaycar Electronics but the table at right lists some of the more "esoteric" components.

Most of these were sourced, via ebay, from China. This can result in a delay of 3-4 weeks (or more).

This also applies to the PCBs that are only available from the developer in Portugal. To purchase them you will need to sign up at www.meteocercal.info/forum/ and send the developer, Werk_AG, a Private Message to start the process. I'd do this first to get the ball rolling.

Where possible, order all of what you need from one supplier at a time.

FS1000a Transmitter Module



Specifications:

- Transmission Distance: 20-200m (higher voltage, longer range)
- Idle current: 0mA
- Working current: 20-28mA
- Working voltage: 3-12V
- Transfer rate: 0-10kbps (ideally 2400bps)
- Transmit Power: 10-40mW
- Transmitting frequency: 433.92MHz
- Modulation: OOK (ASK)
- Working temperature: -10°C to +70°C

KXD-10036 RF Transmitter/ Receiver Module 433MHz

This can save you postage costs with some suppliers.

Note – Arduino Nano

We are recommending the Nano that has the CH340G chipset onboard now, as there have been problems with FTDI (fake) chipset drivers since FTDI and Microsoft sent an update that bricked the Nanos with the fake FTDI chip.

If you use the recommended CH340G then you will need to download the Windows driver.

You can read about this and download the driver (**CH341SER.zip**) here: www.meteocercal.info/forum/Thread-Arduino-Nano-USB-Driver

Next month:

In Part 2 of this series, we will get on to construction, specifically, the TX unit – and look at programming the Arduino Nano using the Arduino IDE.

ebay item numbers for hard-to-get or unusual items

		ebay item no.#
TX Unit		
1	TX_PCB WeatherDuino Pro2 TX board v4.0x	(from MeteoCercal)
1	IRLZ44N	181092926231
	(also available in Australia from element14 – order code 8651418)	
1	TMP36 (Optional case sensor)	181092361353
1	Arduino Nano v3.0	141287851903
1	FS1000A, 433MHz TX Module	180929057924
1	433MHz antenna	281126334076
1	SMA Female Panel Connector with Pigtail	290916092362
1	SHT10 Digital Temperature And Humidity Sensor Module	271665110416
RX Unit		
1	WeatherDuino Pro2 RX board	(from MeteoCercal)
1	Arduino Nano V3.0	141287851903
1	DS3231 Real Time Clock Arduino Module	400503978923
1	BMP180 (Recommended!) Barometric Pressure Module (or BMP085)	400694164288 191092156809
1	DHT22 Temperature / Humidity Sensor	170931111400
1	BX-RM06 ASK OOK RF Receiver	200974005470
1	ST7735 1.8" TFT	370695363746
	(*or* 20x4 alphanumeric LCD)	310575296583
	(*or* 16x2 alphanumeric LCD with IC2 module)	190847340801
1	433MHz antenna	281126334076
Wireless Display		
1	WeatherDuino Pro2 WD board	(from MeteoCercal)
1	Arduino Nano V3.0	141287851903
1	DHT22 Temperature / Humidity Sensor	170931111400
1	BX-RM06 ASK OOK RF Receiver Module 433MHz	200974005470
1	1.8" TFT - ST7735 160x128	370695363746
1	(*or* 2.2" TFT - ILI9341 320x240)	200953728196
1	(*or* 2.4" TFT - ILI9341 320x240)	181500077459
1	(*or* 20x4 alphanumeric LCD)	310575296583
1	(*or* 16x2 alphanumeric LCD with IC2 module)	190847340801
Optional (required if you want to relay data to a Wireless Display)		
1	KXD-10036 RF Transmitter Module 433MHz	200974005470
1	433MHz antenna	281126334076
Miscellaneous		
1	SMA Female Board Connector	290646661508

The ebay item numbers shown here may well be sold or no longer available; however if you search for these numbers within ebay an identical device, currently available (and often from the same seller) will usually be shown. Many of the ebay-sourced parts came from the one seller. SC

LOOKING FOR PROJECT PCBS?

PCBs for most* recent (>2010) SILICON CHIP projects are available from the SILICON CHIP On-Line Shop – see the On-Line Shop pages in each issue or log onto siliconchip.com.au/shop.

You'll also find some of the hard-to-get components to complete your SILICON CHIP project, plus back issues, software, panels, binders, books, DVDs and much more!

Please note: the SILICON CHIP OnLine Shop does not sell complete kits; for these, please refer to kit suppliers' adverts in each issue.

*PCBs for some contributed projects or those where copyright has been retained by the designer may not be available from the SILICON CHIP On-Line Shop

"Touch Shield" for ARDUINO™

Design by Brandon Speedie#
Words by Brandon Speedie and Ross Tester

This simple Arduino shield adds versatility to your Arduino project for minimal cost. It gives you three touch "pushbuttons" (ie, there's no switch as such) along with a touch-activated "level control".

Into Arduino? It is arguably now the most popular microprocessor platform in the world and has a large, loyal and rapidly growing following here in Australia.

(Please, no arguments from RaspberryPi/PIC/PICAXE/Beagleboard/BASIC Stamp/Atmel/etc aficionados!)

Arduino is one of many open-source electronics prototyping platforms, a "motherboard" base onto which you add "daughter boards" known as "shields" to do, well, almost anything. You think you've just thought of something Arduino can't do? Don't hold your breath: someone, somewhere in the world is probably working on that something at this very moment!

As we report elsewhere in this issue, Arduinos have even gone into space as the control computer for amateur rocketry.

At SILICON CHIP, we've presented several Arduino projects in recent years but we plan on doing a whole lot more in the future, such is the popularity of Arduino.

In fact, starting on Page 30, there's the first part of an Arduino-based weather station.

Human interface

We're kicking this off with a shield which makes it easy to add a "human interface" to any Arduino project. Human interface simply means something which will allow you – the human – to control, or interface, with the Arduino.

This particular project is simplicity itself. It has three pushbuttonss, simply labelled 1, 2 and 3, which can be programmed to do whatever you want them to. It also has a "slider" which is a pattern etched into the printed circuit board (PCB), which with the right software (and we'll look at this later) can become a volume control (up and down), a level control . . . again, just about anything you want it to do.

Each of the buttons and the slider work by capacitive sensing, which means you don't even have to touch them, and some clever software. This tells the Arduino what is being "pushed" or "slid" - it's then up to the Arduino to work out what that specific push or slide means.

The circuit

There's not much to the circuit, as you can see in Fig.1. Each sensing element is connected to two pins on the Arduino, so it knows which button/slide is being used. The pins can be any GPIO (general purpose input/output). One pin, the receive pin (an input) is connected directly to the sensing element. The other pin, the send pin (an output) is connected to the same element via a high value resistor (10MΩ).

The software toggles the state of the send pin, then measures the time it takes for the receive pin to transition to this new state. The time (t) for this transition to occur is proportional to R x C – ie, the resistance times the capacitance at the receive pin. Under "normal" conditions, the capacitance remains fairly steady at some arbitrary parasitic capacitance value.

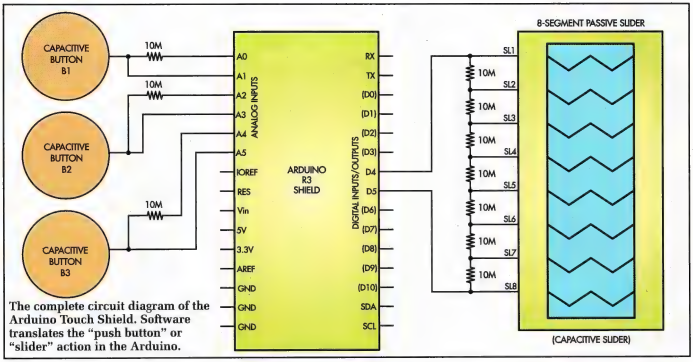
When someone touches their finger on one of the sensing elements – or even comes close – the value of capacitance will change, because the finger changes the dielectric of the "capacitor". It was air, now it's flesh and blood.

Because the capacitance changes, this obviously changes the time (t) it takes for the receive pin to toggle its state – and it is this change that can be used to sense touch.

The slide pot

This works in a very similar way to the pushbuttonss but instead of just two connections, there are multiple elements (tracks on the PCB) each wired in series via 10MΩ resistors. So as the finger moves from track to track to track, the capacitance changes with each track and the time changes as well.

So the position of the finger can be sensed – when it is near the bottom, the resistance is very low so the time (t) is very fast. As the finger moves up the slide, more and more resistors come



The complete circuit diagram of the Arduino Touch Shield. Software translates the "push button" or "slider" action in the Arduino.

into circuit so the time gets longer and longer.

Again, the sofware measures this time and with this information, the Arduino can sense just where the finger is on the slide.

Exactly how it uses this data is up to the software . . . and you!

Construction

We haven't even bothered with a component overlay for this project as it is so simple – the photographs of the front and rear of the PCB more than adequately show what goes where.

There's also no need to show resistor value because all are the same, 10MΩ. However, these are surface-mount devices (SMDs) so it's not quite the same as soldering in through-hole devices. You'll find a guide to soldering SMDs in SILICON CHIP October 2009, page 42.

The only other components to be soldered to the PCB are the Stackable Headers, which allow you to connect to the Arduino board.

There are four headers: one 6-way, two 8-way and one 10-way. Obviously, these mate with the same number of holes on the PCB – a 10-way and 8-way alongside the "slider" tracks and an 8-way and 6-way on the opposite edge of the board, alongside the pushbuttonss. These are all mounted on the top side of the board (ie, opposite side to the SMD resistors).

Be very careful when soldering these in as the pins are very close together. And, **most importantly**, do not cut off the header pins when they're soldered in. Otherwise you won't be able to connect to the Arduino board!

And that's it – the project is complete. We're not going to attempt to tell you how to connect to the Arduino and run the software – if you need to know this, then this project probably isn't for you. At least not yet!

Arduino capacitive software

But we will tell you where to find the Arduino Capacitive Touch Library (by Paul Badger). You'll find this at http://playground.arduino.cc/Main/CapacitiveSensor?from=Main.CapSense

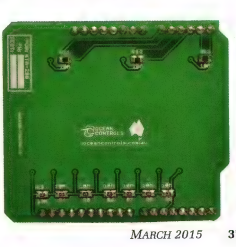
Where to get the kit

This project comes from Ocean Controls Pty Ltd who hold the copyright on the design and PCB.

A kit containing the PCB and 10 x 10MΩ resistors is available from Ocean Controls for $14.95 (SKU KTA298). The four pin headers are NOT included in the kit (available separately from Ocean Controls for $2.30 – SKU SFA007).

See their website to order: www.oceancontrols.com.au

 # Ocean Controls Pty Ltd



(Left) top view and (right) underside view of the Arduino Touch Shield. All components – what there are of them – solder to the underside. The zig-zag pattern forms the slider control. The photo opposite shows the Touch Shield attached to the Arduino, via the pin headers seen top and bottom in the photo at right. More Arduino shields can be added as desired but obviously you'd want this shield to be on top to allow access to the push buttons and slider control.

Building the SPARK ENERGY METER

Part 2 – By Dr Hugo Holden and John Clarke

Last month we introduced our new Spark Energy Meter, an essential workshop tool for anyone who tinkers with automotive ignition systems – old or new! Now we get to the good bit: putting it all together . . .

The Spark Energy Meter is built on two 111 x 85mm PCBs, which stack horizontally inside a 119 x 94 x 57mm diecast box using 9mm spacers.

The first board, coded 04102151, contains the majority of components, with the exception of the 30 x 100V zener diodes – these are all on the second board, coded 04102152.

A power switch protrudes out from the side of the box, while the power LED and high range LEDs pass through the lid. The LCD is also attached to the case lid.

Before you start assembly, place the zener diode PCB centrally in the bottom of the diecast box and mark the positions of the four 3mm holes used for mounting. You can drill these holes now or later.

Construction

The complete parts list (along with the circuit diagrams and descriptions) were included in Part 1 last month – refer to that article for all components.

Start by fitting 100V zener diodes ZD1 to ZD30 on the second PCB (see Fig.3). These all face the same direction on the board but the tracks underneath actually connect them with 15 in one orientation and 15 in the other.

The connection to the spark plug is made via an M205 fuse clip. The fuse tab toward the plug bends down and around the edge and under the PCB. The fuse tab toward the zener diodes is broken off by bending this backward and forward repeatedly with a pair of pliers. Just a few times will cause it to break off.

Strip a few mm of insulation from each end of a 200mm long mains-rated wire and terminate one end into the HV output on the PCB.

Cover the wire in heatshrink tubing, leaving sufficient wire free at the other end for termination into the HV terminal on the second PCB.

Now move onto the other PCB. Fig.4 shows the component overlay. Install the small resistors first.

The resistor colour code is shown opposite but it's always wise to double check each value with a digital multimeter. Leave the 150Ω 5W resistor for later.

Diodes are next and as they're polarised, they need to be installed with the striped end oriented as shown in the overlay diagram. Note that there are several types. D1-D4 are UF4007, D5-D14 are BAT46, D15 a 1N4148 and D16 a 1N5819. Zener diode ZD31 can also be installed now.

Solder the ICs next, with pin 1 toward the top of the PCB (S1 side) in each case. Be sure that the correct IC is placed in each position. REG1 and Q1-Q3 can go in next.

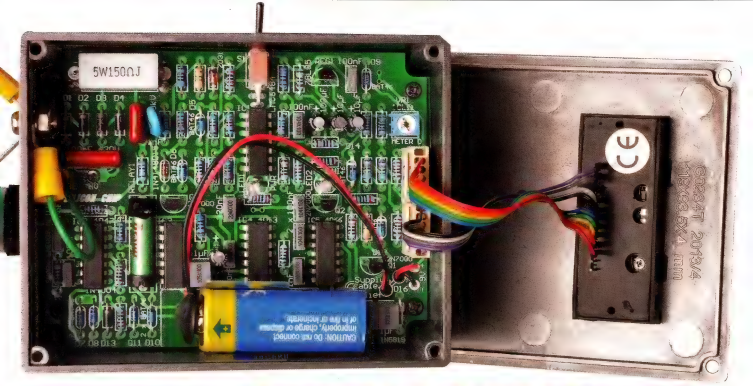
Now fit the capacitors, starting with ceramic and polyester which of course are not polarised. Note the positions for the 100nF capacitor, the 10nF 630V (or 3kV) and the 1nF 100V (or 3kV) ceramic types.

These have a higher voltage rating than the remaining capacitors. The electrolytic types are polarised and must be inserted the right way around – the longer lead is the + side.

Install the reed relay now, then trimpot VR1. Switch S1 is fitted directly to the PCB and the two 6-way pin headers for the LCD can also be soldered in, along with the two PC stakes and adjacent 150Ω 5W resistor.

LED1 and LED2 are mounted so that the top of each LED is 31mm from top surface of the PCB. Take care that the anode (longer lead) is placed in the component hole labelled "A".

The 9V battery holder is secured to the PCB using a countersunk M3 screw and nut with a piece of TOP-3 silicone



washer between it and the PCB. The washer is trimmed to size with scissors and a hole cut in the centre for the screw. There will already a hole in the silicone washer (due to it being punched for the TOP-3 package) but this will be in the wrong position.

Wires for the 9V battery clip are passed through the PCB holes as shown for strain relief, helping to prevent the wires from breaking due to flexing, when terminated to the 9V inputs. The red wire is terminated to the + side, black to –.

A short 70mm length of 7.5A 250VAC mains wire (green or black) is terminated into the 'CASE' terminal and the other end crimped to a crimp eyelet.

Box bits

If you haven't drilled the mounting holes in the box, do so now. If using countersunk screws, countersink the holes on the outside of the box.

Fig.5 shows the hole positions for the spark plug and earth screw hole on the end of the box and the switch hole on the side of the box.

For the spark plug, (which, as mentioned last month, needs to be of the resistor variety) this needs to be drilled smaller than required and then carefully reamed out.

There will be a diameter close to 13.5mm where the spark plug will screw in, cutting some thread but mainly held in place by friction.

Note that the PCB is designed for a spark plug with a 12.7mm reach. If

Resistor Colour Codes

Qty	Value	4-Band Code(1%)	5-Band Code (1%)
2	10MΩ	brown black blue brown	brown black black green brown
1	9.1MΩ	white brown green brown	white brown black yellow brown
1	5.1MΩ	green brown green brown	green brown black yellow brown
1	1MΩ	brown black green brown	brown black black yellow brown
2	510kΩ	green brown yellow brown	green brown black orange brown
2	470kΩ	yellow violet yellow brown	yellow violet black orange brown
1	270kΩ	red violet yellow brown	red violet black orange brown
1	240kΩ	red yellow yellow brown	red yellow black orange brown
1	220kΩ *	red red yellow brown	red red black orange brown
1	180kΩ	brown grey yellow brown	brown grey black orange brown
1	150kΩ	brown green yellow brown	brown green black orange brown
4	100kΩ	brown black yellow brown	brown black black orange brown
1	91kΩ	white brown orange brown	white brown black red brown
1	68kΩ	blue grey orange brown	blue grey black red brown
1	62kΩ	blue red orange brown	blue red black red brown
1	33kΩ	orange orange orange brown	orange orange black red brown
4	20kΩ	red black orange brown	red black black red brown
3	10kΩ	brown black orange brown	brown black black red brown
1	8.2kΩ	grey red red brown	grey red black brown brown
1	5.1kΩ	green brown red brown	green brown black brown brown
1	1.5kΩ	brown green red brown	brown green black brown brown
1	1kΩ	brown black red brown	brown black black brown brown
1	240Ω *	red yellow brown brown	red yellow black black brown
1	200Ω	red black brown brown	red black black black brown
1	100Ω *	brown black brown brown	brown black black black brown
1	150Ω 5W	(value printed on resistor body)	
2	47Ω	yellow violet black brown	yellow violet black gold brown
1	10Ω *	brown black black brown	brown black black gold brown

* For calibrator

Capacitor Codes

Value	µF value	IEC code	EIA code
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
47nF	0.047µF	47n	473
10nF	0.01µF	10n	103
1.0nF	NA	1n	102

a longer reach spark plug is used (as we did), use a spacer to cover the bare thread that's exposed on the outside of the case. This spacer can be seen in the photo above.

The LCD module is mounted onto the lid of the case. The label artwork, which shows the positioning for the LCD module and the LED holes, also makes a great template. It can be photocopied or downloaded from the SILICON CHIP website (see panel).

The rectangular cut out is made by drilling a series of small holes (eg 2-3mm) inside the perimeter, then knocking out the piece and filing to shape.

The PCBs are attached to the box using 9mm stand-offs. Four stand-offs, held by 12mm x M3 screws, are placed in the base of the case. Next comes the lower PCB, followed by the set of four spacers screwed onto the remaining thread of the screws.

The earth tag on the spark plug that bends around to face the inside insulated electrode is removed. This can be done using pliers to bend the tab back and forth to shear it off. Then file the rough edges down.

Screw the spark plug in to make contact between the centre electrode and the M205 fuse clip on the PCB.

The second PCB stacks on top of the first. This is done after the interconnecting wire between the HV terminals on each PCB is connected. The top PCB is secured with the M3 x 5mm screws.

The crimp eyelet is secured to the case with an M4 screw, star washer and nut with the spade connector attached on the outside of the box using the same screw.

Wiring the display

The 9-way rainbow cable is stripped into a 5-way length and a 4-way length. Separate out the wires for about 100mm on one end and strip off the insulation by about 1mm on this end of the cable.

Terminate to the LCD terminals and solder in place after a short length of heatshrink cable is placed over each wire. The heatshrink supports the wire to prevent breakage.

Note that the connection pins on the rear of the display are numbered from 1 to 13, but with pin 3 missing and left as a blank space. This separates the power at pins 1 and 2 from the remaining pins. Pin 4 is not used.

The other end is terminated into the header plugs and the metal contacts. These are designed to crimp the wires and then hold the wire and insulation using another set of bendable pieces on the terminal.

Use pliers to crimp these down. A small amount of solder applied to the crimped connector where the wire is crimped will prevent the wire slipping out from the connector.

The crimp connectors are slid into their backing shells and pressed in using a small screwdriver till they click in place. Make sure the LCD module is wired correctly before applying power.

On power-up (when the 9V battery is connected or a separate supply), the power LED should show ".000"

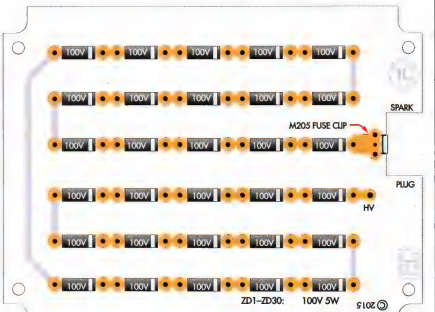


Fig.3 (above) is the component overlay for the zener diode PCB. All zeners are oriented the same direction, so construction is easy! Below is a matching photo of this board, again printed very close to life size. The fuse clip on this board is obscured by the spade lug insulator.

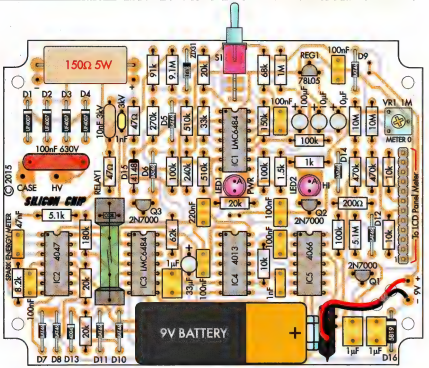
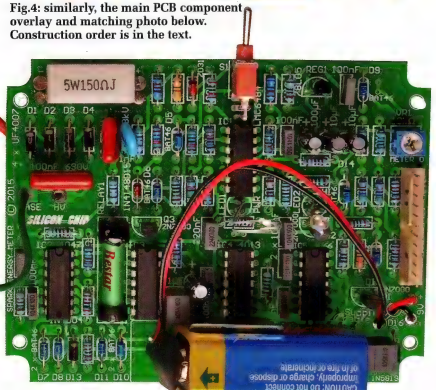


Fig.4: similarly, the main PCB component overlay and matching photo below. Construction order is in the text.



or close to it. VR1 can be adjusted to set the display to zero if needed.

If the display does not show these numbers, check wiring between the PCB and display.

Finally, make up a lead to connect to the spade connector on the case of the Spark Energy Meter. This comprises the remainder of the 1m mains wire with an alligator clip on one end and a crimp spade connector on the other. This is used to connect to mains earth when testing the spark from an ignition coil.

If you need a suitable ignition coil driver then the High Energy Ignition from November and December 2012 includes a spark test feature where the coil is driven to check ignition operation.

Calibrator construction

The Spark Energy Meter Calibrator is constructed using a PCB coded 05101153 and measuring 47 x 61mm. The PCB will clip into the side pillars in a standard UB5 utility box (83 x 54 x 31mm) although we present this as a bare PCB. Note that there are two versions, the calibrator and the PWM driver, so follow the overlay diagram for the version you are building.

The PWM circuit will produce an approximately 500Hz waveform. Depending on your application, this may be too high. For a small DC motor for example, a 100Hz drive may be more suitable. The 10nF capacitor can be changed. Use a 47nF for a nominal 100Hz PWM drive.

Follow Fig.6 for the PCB assembly. Install the resistors first. These are colour coded with the resistance value as shown in the table overlaf. A digital multimeter should also be used to confirm the values. Note that for the calibrator, there is a wire link required between VR1 and VR2. This wire link is replaced with a 1N4148 diode if the alternative circuit is built.

Diodes are next and these need to be installed with the correct polarity with the striped end oriented as shown in the overlay diagram.

Install the IC now noting the correct orientation for pin 1. REG1 and Q1 can then be installed. These lie horizontally

Accounting for the 150Ω wirewound resistor tolerance

Even though you normally set the calibrator to give exactly 5V output, the reading on the Spark Energy Meter could be ±5% out due to the tolerance of the 150Ω 5W wirewound resistor at the input (ie, it could be anywhere from 143Ω to 157Ω). Wirewound resistors are not known for their tight tolerance!

So your reading (which depend on this resistor) could also be out.

If you want it exact, the way around this is to measure the resistor and compensate. If you happen to measure exactly (or even *very* close to) 150Ω , you don't have to do anything. But if it's out, set the voltage from the calibrator higher or lower than 5V by the ratio of your resistor to a perfect (150Ω) resistor.

For example, if your resistor measures 155Ω , set the voltage to 155/150 x 5, or 5.17V. Conversely, if it's lower, say 145Ω , set the calibrator output voltage to 145/150 x 5, or 4.83V.

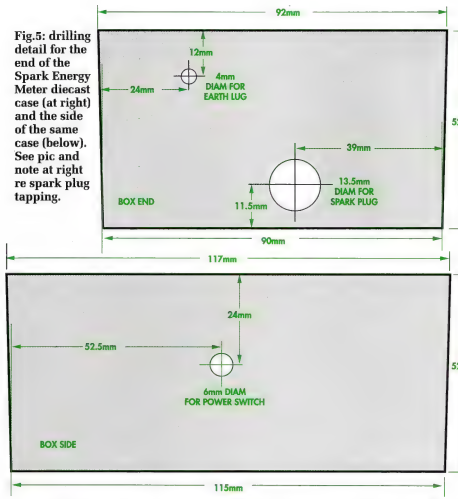


Fig.5: drilling detail for the end of the Spark Energy Meter diecast case (at right) and the side of the same case (below). See pic and note at right re spark plug tapping.

Drill and ream the spark plug hole through the end of the case to a size *just* smaller than the plug thread, then use the plug thread itself to "tap" the softer aluminium. This will make the spark plug captive.

on the PCB after the leads are bent over by 90 degrees to fit into the mounting holes. The metal tabs can be held against the PCB using M3 x 10 screws and M3 nuts if required.

Q2 and Q3 are mounted next, taking care not to transpose them. The capacitors can be installed next; the electrolytic types with the polarity shown. Install the three PC stakes, along with the trimpots and the two 2-way screw terminals. These are oriented with the wire entry toward the outside of the PCB.

Testing and setting up

Apply a 7-12V supply to the input screw terminals. Connect a multimeter to the 0V and 5V PC stakes and adjust VR1 for a reading of 5.0V. The second adjustment requires access to a frequency meter. Many multimeters now include frequency metering and will be suitable for the 250Hz setting.

Alternatively an oscilloscope can be used. Using the test point TP1 and the 0V PC stake as the common connection, adjust VR2 for 250Hz. On an oscilloscope this will be a square wave with a 2ms high level duration and a 2ms low duration.

For calibration of the Spark Energy Meter, the plus (+) terminal on CON2 of the Calibrator connects to the plus (+) PC stake on the Spark Energy Meter. Similarly, the minus (-) terminal on CON2 of the Calibrator connects to the minus (-) PC stake on the Spark Energy Meter.

Make sure the calibrator is powered by a different supply to the Spark Energy Meter and that at least one supply is floating with respect to earth (ie use a battery for one supply). Switch on the Spark Energy Meter and calibrator and adjust the trimpot within the LCD module for a reading of 100mJ.

Using it

There are two ways to use the meter. Firstly, the meter's ground connection is clipped onto a secure ground point to avoid the meter body developing a high voltage potential during the spark.

The spark plug wire can be lifted from one of the engine's spark plugs and plugged onto the meter spark plug input. Then with the engine running (which will have a miss as one spark plug is not operational), the meter reads that spark energy in milliJoules (mJ). This can be done for all the engine's spark plug feeds for comparison, one at a time.

In a 4-cylinder car, the frequency of the sparks presented to a single plug by the distributor is about 4Hz when the idle rate is 500 RPM.

Some cars which have an individual ignition coil per spark plug with custom assemblies can also be measured if

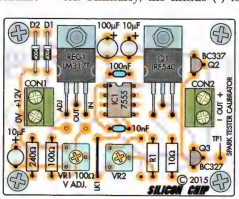
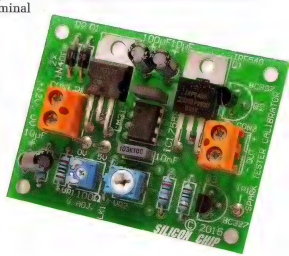


Fig.6: the calibrator PCB component overlay and an enlarged photo (for clarity) alongside. Trimport VR1 adjusts for exactly 5V output (or calculated output to account for wire-wound resistor tolerance – see text). VR2 adjusts for the correct frequency at 250Hz.



an appropriate connector system is made to access the high voltage terminal where the spark is normally generated and using a non-powered dummy coil/plug module to re-seal the combustion chamber.

The second way to use the meter is to disconnect the ignition coil from the distributor and measure the its output directly while cranking the engine (naturally, the engine will not start).

This will give a higher energy reading as it bypasses the losses in the distributor's spark gap and the differences in these measurements will give an indication of the distributor's spark losses.

In systems with wasted spark or two terminal ignition coils as in Commodore and many General Motors engines, one of the ignition coil outputs is shorted to ground and the other terminal is measured by the meter. SC

Use as a low voltage speed control or dimmer

The calibrator circuit published on page 62 of last month's issue included an alternative PWM Drive Circuit (shown in a yellow panel). This modification can then make this board usable as a 12V DC motor speed control or even a 12V incandescent/LED light dimmer.

See the revised component overlay below.

There is a link (LK1) and a pair of unused pads alongside VR2. Replace this link with a 1N4148 diode (anode towards the PCB edge) and another 1N4148 across the unused pads (same orientation). Two other changes are needed: VR2 is changed from a 50kΩ to 250kΩ (or it could be replaced with an external pot if that's more convenient) and R1 is reduced from 220kΩ to 1kΩ .

A 12V motor or lamp needs to be run from the incoming 12V supply (at CON1), not the + output terminal on CON2, which is at 5V. You take +12V DC from the CON1 + input terminal and connect the 0V to the CON2 – output terminal, as shown below.

Obviously, if you have a 5V motor or lamp, you can use both "normal" output terminals, CON2.

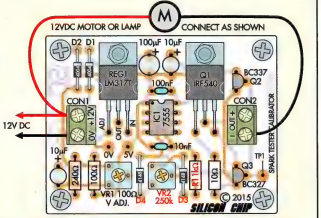


Fig.7: the changes (shown in RED) required to turn the calibrator circuit into a 5V or 12V motor speed controller or incandescent/LED lamp dimmer. At 12V, connected as shown above, it will deliver up to 5A if the 12V supply is capable of that current. At 5V, the limit would be 1A, the maximum current allowed through D1 and D2. (The LM317T can deliver around 1.5A).

Producing a great-looking label!

A nice label adds professionalism and a "finish" to your project. The label we have prepared (which also doubles as a template for drilling holes and cutting the LCD readout hole) is shown below, reproduced same size.

You have several options in making a label:

If you have access to a colour photocopier, it can be copied onto paper (either plain paper or photo paper). Or it can be downloaded from siliconchip.com.au and printed on a colour printer. After cutting out (don't forget the LED holes!) it can be glued to your panel with a suitable adhesive or neutral cure silicone. However, this type of label will be easily damaged. It can be laminated (with a hot melt laminator) although this will tend to separate over time.

For a more rugged label, download and print onto clear overhead projector film (using film suitable for your type of printer) as a "mirror image", so the printout will be on the back of the film when the label is affixed. Attach with silicone sealant. A light-coloured silicone will be needed if the lid is black.

Another alternative, and one which is arguably the toughest and longest-lasting, is to use a synthetic 'Dataflex' sticky-backed label that is suitable for inkjet printers or a 'Datapol' sticky label for laser printers and affix using the sticky back adhesive already on the label. Cut out the holes in the label with a sharp craft knife.

These labels are available from www.blanklabels.com.au and sample sheets are available on request to test these in your printer.

Google "blank labels dataflex" or "blank labels datapol" for more information.

Fig.8: full-size label which can also be used as a template.

QuantAsylum's QA400 24-bit 48K/192KSa/s Stereo Audio Analyser

Review by JIM ROWE

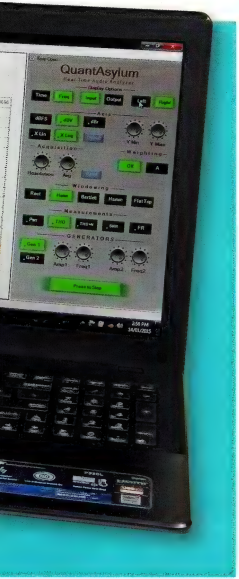
Do you need to perform serious testing of audio equipment on a shoe-string budget? The QA400 Stereo Audio Analyser offers 24-bit sampling at either 48KSa/s or 192KSa/s and achieves a level of performance which closely approaches that of high-end analysers with prices starting at more than $6000 – despite its own price tag of only US$247 including shipping and handling! There are a few catches though.

IF YOU'RE INVOLVED in designing and/or testing audio gear, you may have looked longingly at high-end audio analysers like those made by US firm Audio Precision. But you probably lost interest soon after discovering that their price tags start at about US$6200 and rise rapidly from there.

Is there a lower cost solution? Well, there might be. As you probably realise, nowadays even these high-end analysers are basically a "USB virtual instrument box" with a set of audio CODECs (DACs and ADCs) controlled by software applications running in the PC they're hooked up to. The same software is also used to analyse the audio measurement data collected using the analyser hardware box.

Basically, the main difference between the high-end analysers and much lower cost set-ups like those based on PC sound cards or USB-linked audio interfaces (like the Sound Blaster Extigy, etc) has been in the quality of their hardware, the CODECs and associated circuitry. However, solid-state technology has been racing ever forward, upping the performance of CODEC chips while lowering their cost. And software programmers have been coming up with increasingly powerful, low-priced audio analysis software capable of running on today's PCs.

One result of these is the QA400, from QuantAsylum, which has development offices in the USA (in Snoqualmie, Washington) and China (in Shenzhen).



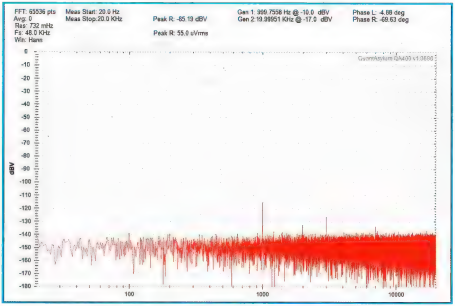


Fig.1: this grab shows the crosstalk into the right channel input (open circuited) when a 1kHz -10dBV signal was being fed into the left channel input from the QA400's generator 1 (via the left channel output), using 48kHz sampling. As you can see the fundamental is at -115dBV, giving a crosstalk of -105dB.

The QA400 comes in a compact aluminium box measuring 175 x 86 x 44mm and weighing a mere 348g. There are no controls on the front panel – just four BNC sockets for the unbalanced or (single-ended) stereo audio inputs and outputs, plus nine LEDs to display the QA400's operating status. There's even less on the rear panel – just a USB type B socket that's used to connect the QA400 to a USB 2.0 port on your PC. The QA400 is powered from the PC via the USB cable, like a dongle.

Inside the QA400 there are a pair of low-noise input channels, each driving an ADC able to perform 24-bit sampling at either 48KSa/s or 192KSa/s (software selectable), plus a matching pair of 24-bit DACs (also 48KSa/s or 192KSa/s selectable) driving low-distortion output amplifiers as software driven audio generators. All of the CODEC functions are apparently provided within a single Cirrus Logic CS4272 high-performance chip. The QA400 also contains USB data interfacing and power derivation circuitry.

The DC input resistance is 100kΩ and the AC input impedance is 10kΩ, with the input clipping level specified as +3dBV/1.41Vrms/4Vpp. A label on the QA400 warns that the signal level at the inputs should not exceed +6dBV, while the maximum DC input level should not exceed ±5V (the label also reminds the user that the QA400 shares its grounding with the PC). The output channels have a low but unspecified output impedance and a rated maximum output level of +3dBV/1.41Vrms/4Vpp – the same as the clipping level of the input channels. The QA400's rated current consumption from the PC USB port is approximately 300mA – well within the maximum level of 500mA.

The unit comes with a 2m-long USB cable to connect it to the PC, plus a couple of 1m-long BNC-to-BNC cables which can be used for making "loopback" connections between the outputs and inputs. The whole QA400 hardware package costs the modest sum of US$199.00 plus US$48.00 for shipping and handling to overseas countries like Australia and New Zealand.

Once you've purchased and received the hardware package, you can register on the QuantAsylum website (**www.quantasylum.com**) to download the software. The software installs on virtually any PC running Windows (32-bit or 64-bit) and comes with its own USB drivers because QuantAsylum wanted to achieve a higher level of performance than can be achieved using the Microsoft audio drivers. It also has its own GUI, which you can see in one of the screen grabs (Fig.2). This has a "control panel" on the right and the display window on the left.

Along the top of the control panel there's a row of buttons to select the display options. You can select either the Left, Right or both channels and display either the inputs or the generator outputs. You can also choose to show the display plotted against either time like an oscilloscope or frequency, ie, as an FFT spectrum display. Below these are six further buttons and two mouse controlled rotary knobs, to allow you to select the X and Y axis scaling for the display. The three upper buttons allow selection of dBFS, dBV or dBr for the Y axis, with the two knobs allowing you to set the minimum and maximum values (so you can examine small variations more easily).

Two of the lower three buttons in this group allow you to choose either a linear or logarithmic scaling for the X axis (Frequency or Time). The third and slightly smaller button is labelled "Default", and is used to reset both axes to their default scaling.

Just below the Axis controls are two knobs on the left to adjust the Acquisition settings – Resolution (2048 - 131,072 points) and Averaging (0 - 50). To their right are two buttons

The QuantAsylum QA400 stereo audio analyser comes with a 2m-long USB cable to connect it to a PC, plus a couple of 1m-long BNC-to-BNC cables which can be used for making 'loopback' connections between the outputs and inputs.

under the "Weighting" label, which can be used to either turn off or select an "A" weighting filter.

Next down on the control panel are five buttons, used to select an FFT Windowing function with a choice of Rectangular (Dirichlet), Hanning, Bartlett (triangular), Hamming or Flat Top.

Further down again are the Measurement selection buttons to select Pwr (Power), THD (Total Harmonic Distortion), THD+N (Total Harmonic Distortion + Noise), SNR (Signal to Noise Ratio) and FR (Frequency Response). Immediately below these are the controls for the QA400's two audio signal generators. There are two buttons to turn each generator on or off plus four knobs which are used to adjust the amplitude and frequency for each generator. And right at the bottom is the Press to Run/Press To Stop button.

Incidentally, QuantAsylum has built some nice features into many of these on-screen controls. For example, if you click on any of the buttons displaying a black or white dot just to the lower left of its function label, while holding down the Control key of the PC's keyboard, you get a context relevant dialog box which lets you set various key parameters. Similarly the "knobs" are easily controlled by left-clicking them and then moving the mouse wheel with your forefinger to vary their setting.

Another nice feature is that as well as the top Settings menu allowing you to select either 48KSa/s or 192KSa/s sampling, it also allows you to change the graphical display from light traces and text on a black background to dark traces and text on a white background. The former is probably easier to read on a PC's screen but the latter is better for print-outs and also saves ink or toner.

You also have the ability to add, edit or delete a title at the top of the display, the ability to pan and/or zoom the display horizontally in order to examine an area more closely, and add markers to the display traces. You can also copy just the current display window to the Windows clipboard as a bitmap image, for pasting into an image processing application. This is an alternative to the Windows PrtScn option, which lets you save the entire screen to the clipboard.

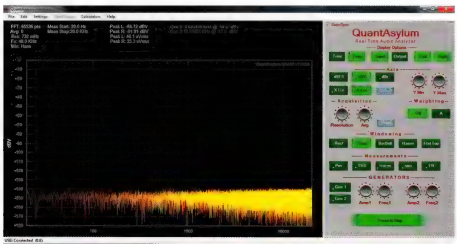


Fig.2: this screen grab of the QA400 Analyser software in operation shows the control panel at right and the display window at left. The traces can be displayed as either light on a dark background as seen here, or dark on a white background to save ink/toner when you print it out.

Claimed performance

You don't have to study the QA400's performance specs for very long to realise how close its basic performance comes to that of high-end audio analysers. For example, those 24-bit ADCs and their low noise input amplifiers are claimed to provide a noise performance over the audio range 20Hz-20kHz of -104dBV with high source impedances at the inputs, or -102dBV with low source impedances.

The claimed overall (loopback) performance is also very impressive. With Hann windowing, 32K points, no averaging, no weighting and a 20Hz -20kHz measurement bandwidth, the THD for a 1kHz/0dBV signal is specified as less than -102dB/0.0012%, while that for a 1kHz/-10dBV signal is below -108dB/0.00055%. Similarly the THD+N for a 1kHz/0dBV signal is less than -98dB/0.0014%, and that for a 1kHz/-10dBV signal is below -89dB/0.0038%. The loopback frequency response over the same 20Hz-20kHz range is listed as ±0.07dB.

After noting these specifications in

particular, I ordered a QA400 from QuantAsylum via the web and then waited impatiently for it to arrive. When it did, I lost no time in putting it through its paces, hooked up to an Asus P550L laptop with an Intel Core i7 processor running Windows 7 Pro (64-bit) at 2.0GHz.

What we found

There were no problems installing QuantAsylum's Real Time Audio Analyser application (V1.0696) and when I fired up the application, I found that the 57-page QA400 User Manual had also been installed as a PDF file. It turned out to be well-written and easy to follow, although not quite as comprehensive as I'd like (more about this later).

I then plugged in the USB cable from the QA400 and noted that the application recognised it had been connected. Then when I clicked on the "Press to Run" button at lower right on the screen, the green "Run" LED began to glow on the front panel of the QA400 and away it went.

Incidentally, its measured current drain turned out to be 252mA when the software was running. After going through the recommended calibration procedure (which only requires a known-accurate RMS AC voltmeter and a couple of BNC-BNC cables), I then began checking out its basic functions and performance. And the results were quite impressive, comparing very well with the claimed specs.

For example, the overall (loopback) frequency response of both the right and left channels at a level of -20dBV measured +0.02dB/-0.1dB from 20Hz-20kHz, drooping to -0.4dB at 12Hz and 25kHz and reaching -1.5dB at approximately 6Hz and 35kHz (192KSa/s sampling). Note that this test is done using an impulse, chirp or white noise stimulus.

Similarly, the loopback THD (32K points, Hann windowing, no averaging or weighting and bandwidth 20Hz-20kHz) for a 1kHz 0dBV signal measured -101.9dB/0.0008% for the left channel and -99.8dB/0.00102% for the right channel. Lowering the signal level to -10dBV gave figures that were even more impressive: -105.5dB/0.00053% for the left channel and -109.2dB/0.00035% for the right channel.

The corresponding THD+N figures for the same two signal levels were also very good: -98.6dB/0.00118% (L) and -97.5dB/0.00133% (R) for 0dBV; and -91.1dB/0.00277% (L) and -91.4dB/0.00269% (R) for -10dBV. These are all very close to the specs but when I checked the noise performance of the two input channels I found what seemed to be a discrepancy between the traces on the screen display itself and the measurements shown at the top of the display window.

As you can see from the full screen grab (Fig.2), the traces (yellow = left, red = right) show noise peaks which are generally below -140dBV, only occasionally rising to -136dBV at the very top end (>10kHz). Yet the measurements at the top of the display show "Peak L" figures of -86.72dBV/49.1μVrms and "Peak R" figures of -91.91dBV/25.3μVrms.

These figures did vary up and down a bit but at no stage did I see them fall anywhere near the levels suggested by the traces below. I find this rather puzzling; perhaps the "Peak" figures represent an integrated figure over the full bandwidth?

My next test was for channel crosstalk, and here I used the QA400's Generator 1 output (1kHz -10dBV) looped back to the input of either the L or R channel, with the other channel's input left open circuit. Here again the results were impressive when looking at the traces but not as impressive when looking at the measurement readings at the top of the display.

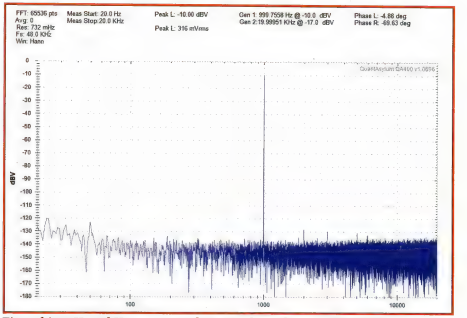


Fig.3: this 20Hz-20kHz spectrum plot was taken when a 1kHz -10dBV signal from the QA400's right channel generator output was being fed into its left input channel. As you can see, the noise and distortion products are below -128dBV for most of the range, rising to -120dBV below 50Hz.

The L-to-R crosstalk worked out at around -105dB using the traces (-115dBV vs -10dBV), yet the "Peak R" figure at the top showed -85.19dBV – corresponding to a crosstalk of only -75.19dB. Similarly, the R-to-L crosstalk appeared to be around -103dB using the traces, but only -74.04dB from the "Peak L" figure.

Although not mentioned in the current version of the User Manual, I noticed that in the application's top menu there's a heading called "Test Plugins". When you click on this you get a choice of two options: Frequency Response or THD Versus Output Level and Frequency. These seem to be swept-frequency test options (in the form of bolt-on DLLs), so that the QA400 Analyser app can be programmed to perform these additional tests.

When I tried these tests, I discovered that their results can't be displayed graphically on screen like the other tests. Instead, they can only be exported in the form of a CSV (comma-separated-variable) text file. To plot and/or print the results, you have to import this file into a spreadsheet like Microsoft Excel or some other graphics application able to accept data in this form.

A further comment about features of the QA400 Audio Analyser application: when you move the cursor around the display window it gives you a real-time readout (at the bottom of the display) of the frequency corresponding to its current X position.

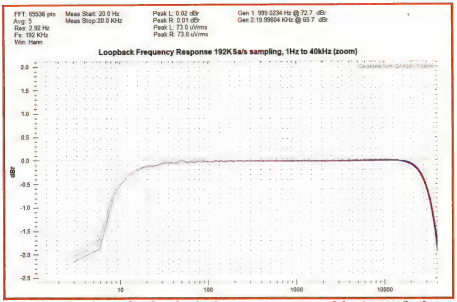


Fig.4: this plot shows the "loopback" frequency response of the QA400 (both channels – red is R, blue is L) over the range from 1Hz to 40kHz, using 192kHz sampling. The -0.5dB points are at 12Hz and 30kHz which is excellent.

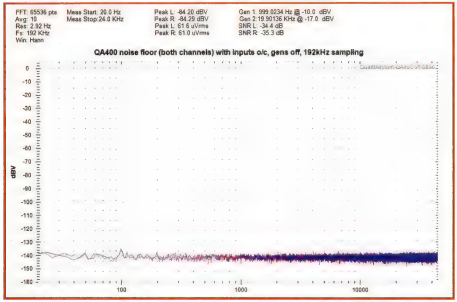


Fig.5: this screen grab shows the noise floor of both input channels of the QA-400, taken over the range 20Hz - 43kHz and using 192kHz sampling, with both inputs open circuited. The noise peaks are below -136dBV over the full range.

This is a useful feature but it would be even more useful if it also gave you a real-time indication of the level corresponding to the cursor's current Y position. That way, you could make on-screen measurements without even placing markers, simply by placing the cursor on any trace position of interest. Hopefully, this feature will be added in a future version of the application.

Now although the QA400 User Manual makes no mention of things like those Test Plugin DLLs and their use, it does have an appendix near the end which gives details of a dot.NET API (Remoting TestApp) which is installed as a zipped file along with the main application, and which can be used to achieve software communication with it. On the QuantAsylum website there's also a note advising that users can make their own Test Plugin DLLs for use with the QA400 Analyser app, writing them in C#, C++ or Visual Basic. You can also download another API called "QA Connection Manager", which makes communicating with the QA Analyser app even easier.

There are also a number of 'white papers' on the website available for downloading, dealing with topics such as: making IMD Measurements with the QA400; Extending the QA400 Noise Floor with an external preamp; and Connecting to the QA400 and other QuantAsylum devices from software written in C++/Managed C++.

Concluding comments

So what's our verdict on the QuantAsylum QA400 hardware and software package? Well, in terms of basic performance, it seems to deliver capabilities which really do compare closely with those of high-end realtime stereo audio analysers. This makes the package excellent value for money for those who only want to perform tests on analog stereo equipment and systems.

At the same time, the QA400 does lack some of the features that you'd find on high-end analysers. For example, its inputs can only cope with signal levels up to +3.0dBV (1.41Vrms/4.00Vp-p), so for testing the output of audio amplifiers at power levels of more than 250mW (= 1.414Vrms across 8Ω), you'll need to use external input attenuators.

Another feature you don't get with the QA400 is balanced inputs, which would allow measurements to at the outputs of bridge-mode and ClassD digital amplifiers, as well as balanced line-level preamp or mixer outputs.

Just coincidentally we are currently working on an analog "front-end" project which should overcome these input limitations of the QA400 and other low-cost USB instruments. It will provide balanced/differential and unbalanced inputs, combined with three measurement ranges: 1:1, 10:1 and 100:1.

Another shortcoming of the QA400 Analyser is that it doesn't allow you to display the input channel signals, the residual distortion waveform when you're doing THD or THD+N measurements, or the noise waveform when you are doing SNR tests. Most high-end analysers do provides these facilities, by providing buffered signals which can be displayed on a scope.

Finally, the QA400 doesn't have the ability to cope with digital audio streams either. So if you need to test digital audio systems, you may need to consider one of the newer high-end analysers that do offer these capabilities. Just be prepared to pay a lot more than the QA400's price tag, because the cost of these analysers starts at about US$20,000. SC

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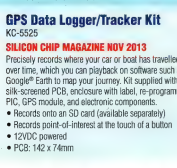

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Ripple Voltage (Max)	150mV	150mV	150mV	150mV
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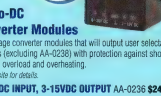

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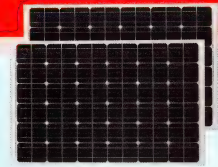

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- **3 X PV CONNECTOR MALE** PP-5102 **$7.50 EA**
- **1 X Y-LEAD 2 SOCKET TO 1 PLUG** PS-5110 **$19.95**
- **1 X Y-LEAD 2 PLUG TO 1 SOCKET** PS-5112 **$19.95**

$810 ZM-9306

SAVE $151.90

$1399

SAVE $211.75

290W Solar Upgrade Deal

TOTAL VALUE $1610.75

Add battery and LED lights for a complete self-sustained power solution.

DEAL INCLUDES:

- **1 X 290W SOLAR PACKAGE** ZM-9306 **$810**
- **1 X 100AH DEEP CYCLE GEL BATTERY** SB-1695* **$379**
- **1 X BATTERY BOX WITH ACCESSORIES** HB-8500 **$89.95**
- **2 X IP67 FLEXIBLE LED LIGHT STRIP** ST-3950 **$89.95 EA**

SB-1695 not stocked in all stores. Check your nearest store for availability

150Ah 12VDC AGM Deep Cycle Battery

SB-1822

Designed to perform in harsh tropical conditions! With a superior high rate discharge performance and higher cycle service life, this battery is perfect for a wide array of applications including remote solar systems, 4WD, caravan, RV, motorhome, and marine applications.

- Small footprint to suit installations in tight areas
- 123(W) x 556(D) x 296(H)mm, 52kg

Not stocked in all stores. Check your nearest store for availability.

$699 DOUBLE POINTS

Solar Panel Mounting Brackets

Your ideal solution for mounting solar panels in caravan, motor home, shed or marine applications. These brackets provide secure and easy mounting, and they also space the panel up to provide the necessary airflow. *See website for full range*

FIXED ALUMINIUM SIDE BRACKET
HS-8780 **$7.95 EA**

FIXED ABS SIDE BRACKETS White.
HS-8862 **$19.95 PAIR**

ADJUSTABLE 45° ALUMINIUM BRACKET
HS-8785 **$59.95 EA**

FROM $7.95

Solar System Cables

Very tough cable, specifically suited for the rigours of outdoor use in solar panel installations. Dust, age and UV resistant, tinned copper conductors to minimise corrosion.

4MM² 50A RATED WH-3121 **$3.50/m**

6MM² 76A RATED WH-3122 **$5.50/m**

FROM $3.50/m

SOLAR SYSTEM ESSENTIALS

$9.95 ea

Power Distribution Posts

Heavy duty stainless steel posts mounted on a moulded plastic base. Three versions available with single connection or bridging plate to suit a variety of power distribution applications.

- 45(W) x 43(L) x 35(H)mm
- Mounting hole: 4.5mm (Dia)

M10 SINGLE SZ-2090 **$9.95**
M8 TWIN SZ-2092 **$9.95**
M6 TWIN SZ-2094 **$9.95**

$9.95 ea

High Current Slow Blow Fuses

Designed for high current protection, these bolt-down fuses eliminates nuisance blowing during temporary, short duration overloads. Commonly used for battery and alternator connections. Fuse holder sold separately.

- Rated up to 32V AC or DC
- Terminal studs 8mm

FUSE 125A SF-1982 **$9.95**
FUSE 250A SF-1984 **$9.95**

ALSO AVAILABLE:
FUSE HOLDER
SF-1980 **$19.95**

DOUBLE POINTS

$29.95

IP66 Circuit Breaker Enclosure

SF-4158

Designed to take the range of DIN rail circuit breakers. Spring loaded clear front cover with padlock tabs, top, bottom and rear cable entry. Suitable for electrical installations or solar applications.

- 4-Way Lockable
- DIN rail included
- 96(W) x 195(H) x 98(D)mm

12V/24V 30A MPPT Solar Charge Controller

MP-3735

Extracts the absolute maximum charging power from your solar panels, giving you up to an extra 10-40% from your solar panels when compared to a normal PWM charge controller.

- 3-stage charging
- 205(L) x 145(W) x 55(H)mm

Suitable for 12V or 24V solar arrays only.
A 12V solar array cannot be used to charge a 24V battery.

DOUBLE POINTS

$249

REDUCE YOUR POWER BILLS NOW!

Wireless Power Monitor MS-6204

The ultimate power monitoring solution for tech savvy users. Monitor your power use in real time from anywhere on your smartphone/tablet/PC with an internet connection. Monitors live power usage, averages, running costs and current flow. Wireless transmitter sends data from the meter box to the control hub. Batteries required.

- Connects up to 5 transmitters

ALSO AVAILABLE:

ELITE BASE MODEL
MS-6200 **$99**

E2 CLASSIC USB MODEL
for data download to PC and charting. MS-6202 **$129**

SPARE TRANSMITTER MS-6203 **$39.95**

$129

REWARDS CARD OFFER

ADD MS-6203 FOR $20*

SAVE $19.95

*Valid with purchase of MS-6200, MS-6202 or MS-6204

EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE* & BE REWARDED WITH A $25 REWARDS CASH CARD ONCE YOU REACH 500 POINTS! *Conditions apply. See website for T&Cs.*

REGISTER ONLINE TODAY BY VISITING:
www.jaycar.com.au/rewards

15% OFF OUR RANGE OF POWER TRANSFORMERS FOR REWARDS CARD HOLDERS*

BUY NOW, PAY NO PAYMENTS* for 6 months. Subject to approval. Minimum purchase $99. See in-store for details.

REWARDS CARD OFFER
15% OFF!

$23.95 ea

20VA Toroidal Transformers

With a low height of only 30mm, these toroids will fit into a 44mm rack case. Low electrically induced noise and high efficiency.

- Simple, quick, single bolt mounting
- Outer/Inner: 74mm/21 x 30mm

9+9 VOLTS MT-2082 **$23.95**
12+12 VOLTS MT-2084 **$23.95**
15+15 VOLTS MT-2086 **$23.95**

REWARDS CARD OFFER
15% OFF!

$27.95

72VA EI Core Transformer

MM-2012

Type 2158 single winding transformer with 200mm fly leads on primary and secondary connections.

See website for our full range of EI Core and specifications.

- 24V, 72VA, 3A rated

REWARDS CARD OFFER
15% OFF!

FROM **$99**

Dielectrically Isolated Transformers

Quality fully-enclosed stepdown transformer with fold up metal carry handles, approved 3-wire power cord & two-pin US 110 - 115V socket.

- 240VAC to 115VAC isolated

120W MF-1080 **$99**
250W MF-1082 **$129**
500W MF-1084 **$229**
1000W MF-1086 **$369**

REWARDS CARD OFFER
15% OFF!

$229

Variable Laboratory Autotransformer (Variac) MP-3080

Encased in heavy-duty steel housing, this unit enables the AC input to a mains powered appliance to be easily varied from 0 to full line voltage (or greater).

- Rated power handling: 500VA (fused)
- Output Voltage: 0 to 260VAC @50Hz
- 165(D) x 120(W) x 160(H)mm

Motor Start Capacitors

Ideal for starting single phase induction motors, these capacitors are suitable for motors operating at up to 400VAC. Lower ranges from 6uF to 12uF also available.

See website for details

- Built-in safety device

20UF RU-6606 **$14.95**
30UF RU-6608 **$14.95**

$14.95 ea

FROM **$29.95**

Marine Grade Switch Panels

WITH CIRCUIT BREAKERS

Can be mounted either vertically or horizontally. 10A, 8A, 6A and 4A rated circuit breakers. Soldered to a 10A rated illuminated rocker switch which have 4.8 QC tabs and are single pole.

- ABS plate with 10A rated illuminated rocker switches

4 WAY SZ-1902 **$29.95**
6 WAY SZ-1903 **$39.95**

NEW

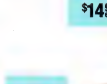
$34.95 ea

Heavy Duty Panel Mount Circuit Breakers

High quality units with multi-wire gauge inputs/outputs, perfect for high powered car audio, automotive or solar installations.

- 85(W) x 68(H) x 35(D)mm

60A SZ-2081 **$34.95**
120A SZ-2083 **$34.95**
200A SZ-2085 **$34.95**



$9.95

IEC EMI Power Line Filter

MS-4003

This industrial standard panel mount RF/EMI filter is designed to reduce line-to-ground (common mode) interference. Rated to 6 Amp and suits mains voltages of 115 to 250VAC.

- UL, CSA, VDE compliant
- Cutout 27(W) x 21(H)mm

FREE HEATSINK TO SUIT FOR REWARDS CARD HOLDERS* SY-4085
Valid with purchase of SY-4084 or SY-4086

SY-4085 VALUED AT $9.95

$47.95 ea

Chassis Mount Solid State Relays

These high current relays have dielectrically isolated DC control inputs to control either AC or DC power circuits.

AC TYPE 40A 240VAC TRIAC SY-4084 **$47.95**
DC TYPE 100A 0-30VDC MOSFET SY-4086 **$47.95**

$139 DOUBLE POINTS

CAT III 1000A True RMS AC/DC Clamp Meter

QM-1566

- Cat III 600V, 4000 count
- AC/DC voltages up to 600V
- AC/DC current up to 1000A
- Jaw opening 40mm

$109 DOUBLE POINTS

Cat IV Heavy Duty True RMS DMM

QM-1574

Heavy duty and drop proof up to 2 metres, this IP67 DMM is your best mate in harsh environments.

- Cat IV 600V, 4000 count
- AC/DC voltages up to 1000V
- AC/DC current up to 10A

ESSENTIALS FOR YOUR DIY POWER PROJECTS

FROM **$1.20**/m

2-Core Tinned DC Power Cables

Double insulated 2 core tinned power cable suitable for automotive and marine applications.

See website for single-core power cables.

- Also available in bulk rolls

7.5A WH-3057 **$1.20/m**
15A WH-3079 **$2.66/m**
25A WH-3087 **$3.80/m**
50A WH-3063 **$7/m**

FROM **$4.95**

High Current Power Connectors

Used widely in industry. Genderless. Stackable - make custom configurations.

- 600V rated (AC or DC)
- Sold as a red and black pair

30A PT-4405 **$4.95**
45A PT-4406 **$4.95**
75A PT-4407 **$11.95**

$14.95

Pocket Wire Stripper TH-1817

DOUBLE POINTS

Strips anything from 2G to RG6 coax. Easy to use and small enough to take anywhere on the job. 120mm long.

$15.95

Stainless Steel Wire Stripper/Cutter/Pliers TH-1841

DOUBLE POINTS

Strip wire sizes from 0.6mm to 2.6mm with ease. Features spring-loaded with locking jaws and soft rubber handles for added comfort. 164mm long.

- Strips stranded wire from 12-24 AWG and solid wire from 10-22 AWG
- Will also cut steel wires up to 3.0mm

$14.95
SAVE $5

Power Point and Leakage Tester

QP-2000 **WAS $19.95**

Test your power points using this versatile tester. It checks most types of power points within 110V to 240V for correct wiring and earth leakage circuit breaker trip levels.

$14.95
SAVE $5

CAT III Non-Contact AC Voltage Detector

QP-2268 **WAS $19.95**

Detects AC voltages from 50 to 1000V. The unit will glow green when safe, and flash red and beep when voltage is detected. Batteries included.

- LED flashlight function

$6.95

Waterproof Deutsch 2-Way Connector Set
PP-2150
Perfect for connecting up sensors/lights in the engine bay due to their superior corrosion protection and waterproof properties.
- 13A rated

$12.95

Cigarette Lighter Plug to Merit Socket Adaptor
PP-2098
- 300mm long lead with dustproof cover

$14.95

ANL In-line Fuse Holder
SZ-2078
A solid brass ANL inline fuse holder that is nickel plated. A great looking and functional fuse holder that is suitable for high end car audio installations. Fuses sold separately.
- 95(L) x 50(W) x 36(H)mm

$22.95

Self Powered LED Voltmeter
QP-5582
Easily monitor your battery voltage, or the voltage in any DC powered system. Supplied with a panel mount and a surface mount "hood".
- 5-30VDC
- Connects via 6.3mm spade terminals
- 36(Dia) x 26(D)mm

REWARDS CARD OFFER
4 FOR $40*
SAVE $11.80
*Valid for purchase of SK-0910, SK-0912, SK-0914 or SK-0916

"Condura" Style DC Rocker Switches
Superb looking rocker switches that you see in 70-100ft luxury motor cruisers. All switches come with double-LED illumination, a standard rocker cover and a standard range of decals to customise the switch to your application. Typical decals include: windscreen wipers, horn, heater & many more.
- Rated 20A @12V, 10A @24V

See website for compatible laser-etched covers.

WHITE SK-0910 **$12.95**
RED SK-0912 **$12.95**
BLUE SK-0914 **$12.95**
AMBER SK-0916 **$12.95**

$14.95 ea

Illuminated Pushbutton Switches
IP67 rated for use in harsh environments. All are DPDT NO/NC switches with on-off action.
- Contact rating: 3A @250VAC
- Mounting hole: 16mm

RED SP-0791 **$14.95**
GREEN SP-0792 **$14.95**
BLUE SP-0793 **$14.95**

$9.95

Latching Emergency Stop Switch SP-0786
Essential for installations of industrial or lab equipment. Latching actuator with rotating release. Two sets of contacts: one N/O, one N/C.
- Actuation: Push Off, Rotate On
- Contact rating: 6A @125VAC, 3A @300VAC
- Mounting hole: 22mm

$3.95

Inline JST Switch Kit
SS-0826
JST switch with a male and female JST connector on each end attached to a 140mm wire. Includes mounting bracket and screws.
- 25(L) x 23(H) x 9(D)mm

CONNECTORS AND HOUSING

$7.95

2.1mm DC Connector Set
PS-0785
Features a standard 2.1(ID) x 5.5(OD)mm DC connection supplied pre-fitted to a 100mm pigtail lead, allowing you to make up your own lead set.
- Contact rating: 3A@ 12VDC
- Cables are 20AWG

$9.95 ea

XLR Audio Connectors
Great for use with PA gear and cabling that are used in outdoor conditions.
LINE PLUG PP-1013 **$9.95**
LINE SOCKET PS-1017 **$9.95**

FROM $12.95

2.5mm Audio Connectors
Available in panel mount socket and line plug models.
LINE PLUG With 1m cable PP-0787 **$12.95**
CHASSIS SOCKET PS-0789 **$14.95**

3-Pole Circular Connectors
WITH PE
Range of inline and chasis mount connectors with Pre-Engaging earth contacts for use in harsh environments.
- Contact rating: 16A@ 280VAC/450VDC

CHASSIS PLUG PP-1008 **$12.95**
CHASSIS SOCKET PS-1009 **$12.95**
LINE PLUG PP-1006 **$17.95**
LINE SOCKET PS-1007 **$17.95**

FROM $12.95

FROM $14.95

RJ45 Connectors
Extremely handy for control and communications applications outdoors or industry workshops.
LINE PLUG PP-1452 **$14.95**
CHASSIS SOCKET PS-1450 **$27.95**

$17.95

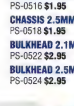
RJ45 Cable Connector Housing
PS-4064
Allows you to join two Cat5e cables while providing a robust and waterproof connection. Includes 2-way Cat5 joiner, but will also accommodate any connector that fits within the internal dimensions of the housing.
- IP Rating: IP68
- Accepts cables: 4 to 7mm Dia
- 120(L) x 35(Dia)mm

NEW

FROM 95c

Plug-In Spring Terminal Blocks
HM-3190
No tools required! Easy-to-use, push-wire terminal blocks suitable for both high and low voltage applications.
- 240V, 24A rated
- Sold in packs of 2

SUITS 0.75 - 2.5MM², 18 - 13AWG:
2-WAY GREY HM-3193 **$0.95**
4-WAY GREY HM-3195 **$1.20**
SUITS 1.5 - 6.0MM² SOLID CORE:
3-WAY RED HM-3190 **$2.45**



PS-0516

FROM $1.95

Chassis Mount DC Connectors
High quality male power connectors.
CHASSIS 2.1MM
PS-0516 **$1.95**
CHASSIS 2.5MM
PS-0518 **$1.95**
BULKHEAD 2.1MM
PS-0522 **$2.95**
BULKHEAD 2.5MM
PS-0524 **$2.95**

$4.95 ea

M8 Circular Connectors
Commonly used in process control instrumentation. All connectors are field installable.
PLUG 3-WAY PP-4300 **$4.95**
PLUG 4-WAY PP-4302 **$4.95**
SOCKET 3-WAY PS-4301 **$4.95**
SOCKET 4-WAY PS-4303 **$4.95**

$5.95 ea

PCB Mount DC Power Sockets
Black colour DC power sockets with snap-in designs.
0.7MM 2A DC SOCKET
with SPST Side Switch.
PS-0532 **$5.95**
2.1MM 5A DC SOCKET
with SPST Rocker Switch.
PS-0531 **$5.95**

ESSENTIALS FOR YOUR POWER PROJECTS

HB-6216

FROM $12.95

IP65 Waterproof Sealed Enclosures
Also designed to NEMA-4 standards, these enclosures are ideal for housing electronics and electrical devices in harsh environments.
See website for full range of sizes available.

ABS DARK GREY HB-6126 **$12.95**
POLYCARBONATE LIGHT GREY HB-6216 **$14.95**
DIECAST ALUMINIUM HB-5042 **$21.95**

300-Piece QC Crimp Connector Pack
PT-4536
This pack contains the most commonly used quick connectors including bullet, ring, fork, spade and joiners in various sizes and colours.
See website for full contents.

TECH TIP!
Beware of other QC connector packs that contain cheap vinyl connectors.

$34.95

BUILD YOUR OWN ULTRASONIC SENSOR

TO MEASURE DISTANCE WITH LIGHT AND SOUND INDICATORS

DOUBLE POINTS FOR REWARDS CARD HOLDERS*

*Valid for purchases of ZC-4895, AB-3462, AU-5550, RR-0680, ZD-1694, XC-4216 or XC-4989.

$2.95 DOUBLE POINTS

8-bit Serial-Parallel IC ZC-4895

Used in many Arduino projects, this handy 74HC595 IC allows you to use 3 valuable lines on your microcontroller for 8 outputs.

- Also functions as a shift register
- 16-pin serial- in/par-out latch

$3.95 DOUBLE POINTS

12VDC Piezo Buzzer AB-3462

This mini unit offers medium to loud sound output, low current consumption and is extremely durable. Supplied with flying leads.

- Operating voltage: 3 - 16VDC
- Max sound output: 90dB

$5.95 DOUBLE POINTS

Ultrasonic Transducer AU-5550

Low power consumption unit with high sensitivity, reliability and stability.

See website for details.

- 2-in-1 transmitter/receiver unit

REWARDS CARD OFFER

BUY ALL 6 FOR $139*

SAVE $44

*Valid with purchase of TS-1564, TS-1566, TS-1567, TH-1862, NS-3094 and TH-1812

48W Lead-Free Soldering Station

TS-1564 **$99**

Features a lightweight soldering pencil with ceramic heating element, and accurate analogue temperature adjustment. Complete with stand and sponge.

- Temperature range: 150 to 450°C

SPARE TIPS:

0.5MM CONICAL TS-1566 **$9.95**

2.0MM CHISEL TS-1567 **$9.95**

$14.95 DOUBLE POINTS

Resistor Pack 300-Pieces RR-0680

This assorted pack contains 5 of virtually each value from 10Ω to 1MΩ.

- 0.5W 1% mini size metal film

See website for full contents.

$24.95 DOUBLE POINTS

LED Pack 100-Pieces ZD-1694

This assorted pack contains 3mm and 5mm LEDs of mixed colours. Even includes 10 x 5mm mounting hardware FREE!

See website for full contents.

- Red, green, yellow, orange LEDs

$16.95

Metal Desolder Tool TH-1862

Quality and lightweight unit with strong suction. Automatically cleans itself with each action.

$17.95

Lead Free Solder

NS-3094

99.3% tin, 0.7% copper lead-free.

- 1mm, 200g coil

EtherTen Bundle

ETHERTEN BOARD XC-4216 **$69.95**

Combining an Arduino and an Ethernet shield onto one single board – includes onboard Ethernet, a USB-serial converter, and even Power-over-Ethernet support. Also features a microSD card slot for storing gigabytes of web server content or data.

- ATmega328P MCU running at 16MHz
- Built-in 10/100base-T Ethernet

CLASS 10 16GB MICROSD CARD XC-4989 **$26.95**

DOUBLE POINTS

*Valid for purchase of XC-4216 and XC-4989

REWARDS CARD OFFER

BUY BOTH FOR $79*

SAVE $17.90

Stainless Cutter / Pliers Set TH-1812

Set of five 115mm long cutters and pliers for electronics and hobbies use. Stainless steel with soft ergonomic grips.

See website for full contents.

$29.95

ARDUINO ESSENTIALS

$2.95

Stackable Header Set HM-3207

The perfect accessory to the ProtoShields and vero type boards when connecting to your Arduino compatible project.

- 2 x 8 pin and 2 x 6 pin included

WC-6021

$3.95 ea

Mixed 10-Piece Jumper Leads

For use in arduino projects, school experiments, or RC and other hobbyist activities. 155mm long.

PLUG TO SOCKET/SOCKET TO SOCKET WC-6021 **$3.95**

PLUG TO PLUG WC-6022 **$3.95**

FROM $9.95

Solderless Breadboards

Three sizes of breadboards to suit all your project needs.

300 TERMINAL HOLES PB-8832 **$9.95**

640 TERMINAL HOLES PB-8814 **$19.95** (Shown)

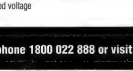
1280 TERMINAL HOLES PB-8816 **$39.95**

$17.95

Mega Prototyping Shield XC-4257

Fits the EtherMega (XC-4256) and Arduino compatible "Mega" size boards. Includes over 300 general-purpose plated holes and header pin sets.

- Handy 5V and GND rails
- 82(W) x 54(H) x 2(D)mm



$9.95

Sound & Buzzer Module XC-4232

Versatile piezo-element module that can be used for both input or output. Includes a built-in 1M resistor to allow the piezo element to detect shocks.

- 1 to 25V rated voltage

$26.95

4-Channel PoE Midspan Injector XC-4254

Power up to 4 EtherTen's (XC-4216) or EtherMega's (XC-4256) with DC from a low cost pluggpack across your home or office network cables. It isolates and powers the correct wires automatically.

- 4 channels of input/output jacks

$29.95

Barometric Pressure Sensor XC-4255

Highly sensitive, ideal for weather, industrial, rocketry, balloon, and many pressure applications. Designed specifically for use as a microalimeter: so sensitive it can detect an altitude change of just 130mm!

- Operating pressure range 10 to 2000mBar
- I2C interface for easy Arduino connection

$49.95

128x128 Pixel OLED Display Module XC-4270

High resolution, full colour 128x128 pixel OLED module perfect for your display needs including graphics, gauges, graphs and interactive displays.

- 16,384 full colour RGB pixels
- 28.8 x 26.8mm active display area
- 44(W) x 36(H) x 5(D)mm

MORE POWER FOR LESS
NEW LOW PRICES UP TO 60% OFF

Below are a number of discontinued (but still good) items that we can no longer afford to hold stock. Please ring your local store to check stock. At these prices we won't be able to transfer them store to store. **STOCK IS LIMITED. ACT NOW TO AVOID DISAPPOINTMENT. SORRY NO RAINCHECKS.**

Versatile LED Display Module For Cars

AA-0375 **WAS $24.95**
Monitor battery voltage, airflow meter or oxygen sensor of your vehicle with this versatile module.
- 12VDC
- 81(L) x 52(W) x 21(H)mm

ALSO AVAILABLE:
FUEL MIXTURE MODULE AA-0374 **WAS $24.95 NOW $19.95 SAVE $5**

20% OFF

$19.95
SAVE $5

CCTV Power Distributor Box

MP-3351 **WAS $39.95**
Distributing power to multiple CCTV cameras with one common source up to 30VDC. Up to 9 slave devices and each protected with PTC output.
- Individual status LED indicators
- 138(L) x 65(W) x 28(H)mm

$29.95
SAVE $10

25% OFF

IR Controlled Wireless Mains Sockets

MS-6158 **ORRP $26.95**
Allow you to switch ON and OFF the mains power to your appliances using your existing remote control. Includes 2 wireless mains sockets and IR receiver unit, slash those hefty energy bills with your fingertip!
- Up to 20m range & 200 sockets per IR receiver unit
- Includes 2 x AA Alkaline batteries (for IR receiver unit)

ALSO AVAILABLE:
SPARE WIRELESS MAINS SOCKET MS-6157 **ORRP $9.95 NOW $4.95 SAVE $5**

60% OFF

$9.95
SAVE $17

POWER ON THE GO

12/24VDC Cigarette Lighter Socket

WITH USB PORT PP-2126 **ORRP $9.95**
Allows you to power a USB gadget while still keeping your cigarette lighter socket available.
- Cigarette lighter plug can be adjusted 180°
- USB output: 5VDC 2A(max)
- Overall width: 60mm

40% OFF

$5.95
SAVE $4

5000mAh Power Bank

MB-3646 **ORRP $59.95 NOW $49.95 SAVE $10**
Don't miss an important call from a client or the family again with this extremely handy USB power bank. All the cables and adaptors sit in small compartments or wrap around the charger for added convenience. Suits Smartphones and tablets.
- Battery capacity 5000mAh
- 113(L) x 58(W) x 15(H)mm

REWARDS CARD OFFER
BUY 3 FOR $99.90*
SAVE $79.95
*Valid with purchase of MP-3646

Retractable USB Cables

High quality and durable retractable leads to avoid annoying tangling and damages.

USB A PLUG TO USB A SOCKET WC-7734
ORRP $14.95 NOW $8.95 SAVE $6
USB A PLUG TO USB A PLUG WC-7735
ORRP $14.95 NOW $8.95 SAVE $6
USB A PLUG TO USB MICRO B SOCKET WC-7736
ORRP $11.95 NOW $8.95 SAVE $3
USB A PLUG TO USB MINI B SOCKET WC-7737
ORRP $14.95 NOW $8.95 SAVE $6

*Valid with purchase of WC-7734, WC-7735, WC-7736 or WC-7737

UP TO 40% OFF

REWARDS CARD OFFER
MIX & MATCH ANY 3 CABLES FOR $20*
SAVE UP TO $24.85

Mains Travel Adaptor for USB

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PRODUCT SHOWCASE

MEC: not your average switches!

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Some applications of MEC switches include studio equipment, door entry controls, military handheld computers, control panels for boats, barcode readers, digital microscopes, internal communication on the Space Shuttle, scooters for disabled people, flight simulators, mixing consoles and petrol pump control units.

They're probably the most flexible switch manufacturer worldwide and pride themselves on providing a solution to any customer's requests. Two examples of their unique range are the Unimec, one of the smallest two-pole switches available today, with contacts capable of producing up to eight functions, depending on the PCB layout; and Foilmec, a solution for switches under foil (an attractive alternative to traditional membrane switches).

Obviously, they're geared towards manufacturers and specific design solutions and would welcome enquiries. MEC are represented in Australia by Control Devices.

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SERVICEMAN'S LOG

The monitor speakers that buzzed

Dave Thompson*

I recently had two speaker systems in for repair, one with an annoying buzz and another that had been damaged during a teenager's tantrum. Both proved to be fixable but it wasn't exactly plain sailing.

After working for many years in sound reinforcement (in a previous life) with local and touring bands, I've seen more than a few speaker systems. They range all the way in size from mammoth stadium-fillers to more discrete systems designed for use in smaller venues. While the amplifiers are often very similar, the speakers are vastly different and knowing which type to use where is often the difference between making someone sound great or making them sound terrible.

I often have a bit of a chuckle to myself when window shopping at the local retailers; some of the speakers sold there are almost laughable, designed more for how they look rather than how they sound. Speakers with flashing lights and oddly-adorned cones seem to be the latest fashion and while some of them sound acceptable, others are downright horrible. The latter are no doubt intended more for assaulting the ears of well-lubricated young people at parties and dances, where the amount of fun is directly proportional to the alcohol consumed and the volume of the bass-heavy racket that passes for music these days.

Of course, the speaker drivers are only part of the equation; the crossovers used will also play a role in the overall quality and listening experience, as will the design of the enclosures and the material used in their construction. Many potentially decent speaker systems have been let down by the on-board crossover filter networks used and poor build quality.

Buzzing monitor speakers

I've had a few speakers through the workshop over the years and was recently asked to look at some rather solid-looking studio monitor speakers that had developed an annoying buzz at certain frequencies. Monitor speakers are designed to have a "flat" frequency response, so that they don't "colour" the audio signal. They tend to be more robust when compared to home stereo speakers, mainly because they are designed for use in recording studios where they may be exposed to raw and unprocessed sounds that could damage their lighter-weight, lounge-room cousins.

To track down the problem, I began by plugging this particular set of speakers into my test-bench amplifier set-up. This consists of an old 50W per channel amplifier and preamplifier combination that I built a long time ago from an ETI design. It was originally my main set-up but has since been relegated to the workshop. It doesn't boast the "hyper-specs" of today's SILICON CHIP amplifier designs but it works well and does the job.

Items Covered This Month

- The monitor speakers that buzzed
- Commercial washing machine repair
- Handymig welder repair
- Miele G2220 dishwasher

*Dave Thompson runs PC Anytime in Christchurch, NZ.
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I use a variety of devices as audio signal sources but, depending on what I'm testing, an MP3 player connected to the Aux channel usually does the trick. Anyway, I gave the speakers a good thrashing and sure enough, at certain frequencies, a very annoying rattle was apparent from the righthand speaker while the lefthand speaker remained clear.

Next, I used a variable frequency audio signal injector (yet another old but trusty magazine design) to see if I could track down the noise source. With music playing, the distortion was audible but fleeting and intermittent and I was hoping that by using the signal generator, I could pinpoint the frequency that causes the rattle.

It didn't take long; at one spot on the dial, the bass driver sounded like a playing card in the spokes of a bicycle. I hoped it wasn't the voice coil binding or something of that nature; replacing speaker cones is no easy task and replacing the driver itself could be expensive.

The first thing to do was to remove the speaker from the enclosure. This was easy enough and just required the removal of the dozen or so PK screws that held it in place. The speaker was also mounted using foam-backed, double-sided tape and even though I was extremely careful, I couldn't help tearing it as the speaker came away from the box. This really didn't matter though; I'd just have to replace it later.

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column? If so, why not send those stories in to us?

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Once it was out, I could fossick around the inside of the enclosure and look for anything obvious that could produce the rattle. I couldn't see anything but that wasn't too surprising as the inside was packed with a shiny, puffy material that I assumed was there to deaden the cabinet.

Before I set about tearing it out or otherwise disturbing it, I plugged the speaker back in and ran it through the audio range again at low volume, paying particular attention to the frequency at which it had rattled before. Sure enough, it was soon making the noise, so it was definitely coming from the driver, not the enclosure.

This was both good and bad news. The good news was that I'd found the source of the problem; the bad news was that fixing a noisy speaker is a lot trickier than repairing an enclosure.

The driver's leads were connected to the crossover PCB via two very tight spade-style connectors that took a fair bit of prying off (these have to be tight to make a good electrical connection and have to maintain that connection in a reasonably hostile sonic environment). Once these were free, I could then inspect the speaker more closely.

First, I gently worked the cone through its range of movement and it moved freely, with no apparent binding or interference. I then wired it directly to my test rig and gradually moved through the frequency range, keeping the volume low initially but gradually increasing it until, at higher volume, the buzzing noise suddenly returned. Frustratingly, I couldn't pinpoint exactly where it was coming from. It emanated from somewhere near the centre of the speaker but where?

I powered it down again and got out my magnifying headset – there just had to be something loose that was causing the speaker to rattle. After poring over it for a few minutes, I suddenly discovered a possible cause; the dome (or dust cap), a small and typically convex cover that conceals and protects the voice-coil and other bits and pieces that live in the centre of a speaker's cone, had come adrift on one side. In fact, it was only when I looked very closely that I could see a tiny gap appear between the dome and the speaker's cone when I pushed gently on the cone.

~I HAD TWO SPEAKER SYSTEMS IN FOR REPAIR, BUT IT WASN'T PLAIN SAILING

In many speakers, the dome is made from the same material as the speaker cone and often helps add strength and structural support to the diaphragm. It can also form part of the acoustical reproduction properties of the speaker, meaning in many instances it is much more than just a dust cover.

In this speaker, the dome was made of a heavy foil-type material and looked to be glued onto the cone beneath. About a third of the circumference of the cap had let go and I could slip a piece of paper easily between the cap and the cone. My theory was that, at certain frequencies, this was oscillating and causing the annoying buzzing noise.

After gently blowing the area clear of dust with my handy rubber air-bulb blower (just like the one the school dental nurse used to use), I hit the edge of the dome with a few drops of superglue, making sure it worked its way underneath and around the unattached rim of the cap. It was then just a matter of applying a "calibrated" pressure on the cap for a few minutes, until it was once again firmly attached to the speaker cone.

A quick test through the audio range confirmed that the buzz was now gone, even at high volume, so the loose cap was indeed the cause of the problem.

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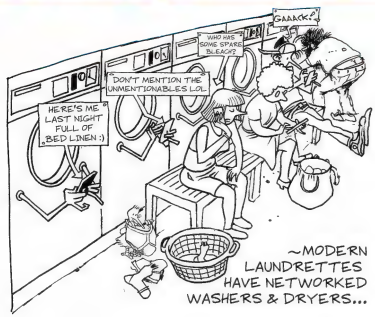


And so, with a sigh of relief, I set about reassembling the speakers. If the problem had been any further into the workings of the speaker it would have meant removing the cone from the frame. And that's not a job I like doing because it takes things well past the point of no return.

Foam sticky-tape

Before remounting the driver in the enclosure I had to scour my workshop for the roll of foam sticky-tape I knew I'd stashed away somewhere for safe keeping. I eventually found it stashed away in a cupboard and it was still sticky enough for the job. I then scraped away the remains of the old tape from the frame of the driver and around the hole in the enclosure and removed any remaining adhesive using a rag soaked in methylated spirits.

Once everything was clean, I stretched the tape around the periphery of the speaker frame and reconnected the driver's leads to the crossover network. It was then just a matter of pulling off the protective backing tape and aligning the driver with the original mounting holes before screwing it back into place. A good thrashing proved that the rattle had gone for good and that the owner would now hear nothing but clean sound from his monitor speakers.

Teenage tantrum

Another speaker repair I was involved with recently was really not so much of a repair as a cosmetic procedure. In this case, a friend's rather emotional teenager had thrown a bit of a wobbly and had kicked out at one of the speakers connected to the family stereo system. While this was no audiophile set-up, it was a well-liked system and the resulting torn speaker grill cloth and "puckered in" speaker dust cap was a continuing source of friction in the household.

In the end, the emotional one's dad brought it to me, hoping I'd be able to fix it and restore some domestic harmony to the home. I'm not a psychologist so I couldn't directly help with his family problems but I did fancy that I could repair the speaker! And if that led to improved family harmony, well so much that better.

With the cabinet on the workbench, the most obvious damage was the foot-sized tear in the semi-transparent material used to cover the front of the speaker. This could prove to be the most difficult part of the repair as this type of material (as far as I'm aware) wouldn't be available from the local fabric shops. That meant that unless I replaced the cloth on both units, this particular cabinet was going to look a bit different to the other one.

Then there was the matter of the damaged driver. The speaker itself sounded fine; it was purely a matter of how it looked, with the dust cap severely deformed and pushed right into the centre of the cone. Even if I could straighten it out, it might very well tear during the process so I put that task on the back-burner while I sorted out the cloth problem.

I cut a piece from the torn cloth and took it to all the material outlets I knew of (there are a lot less around now than there used to be in pre-quake Christchurch). Unfortunately, they all shook their heads and said they didn't have anything like it and wouldn't even know where to get it. Many had fabrics in stock that could do at a pinch so if the worst came to the worst, I'd just replace both speaker grill cloths (I was sure that the owner of the speakers wouldn't be too fazed by this).

I then hit the web, looking specifically for speaker cloth suppliers and found quite a few, none of which were local but a few that offered online sales and inexpensive shipping. A few emails later I had some vendors offering to try to match the cloth if I could provide a decent photo which I duly did. It wasn't long before one replied that they had the exact same cloth in stock and a few metres could be purchased for just $20 plus shipping, a total of $26.50.

That seemed very reasonable, so an order was placed; if it ended up that I had to do both cabinets then at least I'd have enough to cover the job (pun intended!). With that headache out of the way, my next job was to fix the crushed dust cone. There are various methods of pulling these out and it is such a common problem that there are dozens of "how to" videos on YouTube detailing exactly how to go about it.

In the past, I've used a small vacuum pump and a suitable attachment to pull dust cones out. However, this method depends on the extent of the deformation and the material must be solid enough to allow the suction attachment to hold on to it. In this case though, the cap was made of the same porous card-like material as the cone so I doubted that my rig would "grab" it. I tried it anyway only to have my suspicions confirmed – it wouldn't grip at all.

While I've seen people use vacuum cleaners to do a similar job, I was reluctant to try it on this speaker. As a result, I tried another method which involved using duct (or "gaffer") tape to grab the cap. I stuck a strip of tape into the largest of the dents (so that the largest possible area was "grabbed" by the adhesive) and gently pulled the cap

out. It took several goes with the tape but it did the trick and while there were a few creases that would never come out, it would look quite OK through the speaker cloth.

The only other alternative would have been to remove and replace the cap but neither I nor the client was overly keen to go down that road.

When the speaker cloth arrived, it was a simple job to remove the old material from the speaker frame and use that as a pattern to cut and fit the new one. And while it did closely match the other speaker, the original cloth had faded enough to make them look a bit too different, so I ended up doing both after all.

A loose end in the laundry

Washing machines now contain a lot of electronic circuitry, particularly those used in laundromats which can even be interfaced to the internet. N. B. of Taylors Lakes, Victoria recently tackled a puzzling fault in one such machine. Here's what happened . . .

I work in the commercial laundry equipment industry, covering such things as coin-operated equipment, laundromats, industrial laundries and semi-automated laundries in places such as nursing homes and guest houses.

Modern laundromats have networked washers and dryers so that owners can gain real-time reports on coin collection and control their machines remotely via the internet. They can change prices, stop and start machines and view fault reports, all via a mobile phone or fixed internet device.

Washing and drying can be paid for at the machine using either a credit card or coins. Add internet surveillance to these features and the owner can keep an eye on the business without leaving home. These features have been available overseas for some years and more recently in Australia.

A faulty unit that I recently serviced was typical of most modern commercial medium-to-large front load washers. It had two PCB assemblies and an inverter motor drive.

One of the boards provides the display, keypad and interface to the RS232 port on the inside of the washer. This allows the washer price, washer cycles and various features to be programmed when an external computer is connected.

The output/input of this PCB is via an I²C bus to the other PCB which is the control board. This PCB accepts inputs from the water level sensor, a temperature sensor, the door closed and locked switches and the basket speed detector. It then uses this information to control water valves, the drain valve, the direction and speed signals to the motor inverter and the door lock solenoid. It also updates the display and checks for new keypad entries via the I²C bus to the other PCB.

In this case, the fault started months before when the washer stopped mid-cycle with a full basket of water and the display left showing a fixed wash time and not counting down. If the motor or inverter fails with a consequent lack of basket rotation, the display will count down if the processor is running properly and will give an error message at the end of the cycle.

The washer did not respond to key pad presses so I removed the power and then waited before powering it up again. A constant error message now appeared and this turned out to be a power-up error, possibly due to data corruption on the program memory.

To start afresh, we normally cycle the power and hold down one keypad key during power-up. This causes the boot program to halt and await a download from my computer which is plugged into the serial port.

My problem in this case was that the power point was inside a partition behind the machine (this was a laundromat after all) and I was unable to get to the front of the machine in time after applying power in order to press the key to start the download. This was solved by using a power board with a switch on it, along with an extension lead. Once the download had finished, the system was found to operating properly. The customer's cycle information was then written to the washer and it all tested OK.

Unfortunately, that wasn't the end of the matter because the fault returned some months later. When the door was closed and locked, the display went wild, there was no response from the keypad, the motor started and stopped and the buzzer sounded.

I powered it off and on again without unlocking and opening the door but the fault persisted. I then tried powering it off, opening the door and turning it on again. This restored sane operation again but only until the door was closed and locked by the control PCB.

Inverters are notorious for radiating

Handymig Welder Repair

Nothing is more frustrating than having a piece of gear conk out in the middle of a job. B. P. of Dundathu, Qld recently faced up to this sort of problem with his welder . . .

I'd been using my SIP Handymig MIG Welder when the wire feed motor suddenly stopped working. I could hear the transformer that supplies the welding voltage turning on when I pressed the hand-piece trigger but I wasn't getting any wire feed.

I've had this particular welder for over 20 years now and I've done a couple of repairs on it during this time. On this occasion though, I was concerned that the wire feed motor may have failed and that trying to source parts for a unit this old could be a problem.

As I was right in the middle of a welding job, this breakdown was quite inconvenient. There was nothing for it but to investigate further and see if something could be done to get it working again.

After disconnecting the welder from the power supply, I removed the seven screws that hold the side panel/top on and looked inside. When I looked at the wire feed motor, I could see that the two wire connectors that plugged onto the motor terminals looked a bit suspicious. If these weren't making a good connection, that would explain why the wire feed motor had stopped working.

I removed each connector in turn and replaced it again to clean the contacts. Then, with the cover still off, I reconnected the power to the welder and pressed the trigger. The wire feed motor now worked again, so I disconnected the power, refitted the side panel/top and continued with my welding job.

The welder performed faultlessly much to my relief. These units certainly aren't cheap and if the motor had failed, I may have been forced to buy a new welder.

RFI and I knew that the inverter is only powered up when the door is closed and locked. As a result, I decided to carefully check the earth connections in the washer using a DMM, starting at the control PCB and finishing up at the mains lead.

The control PCB has a separate earth wire to the mains connection on the rear panel and this was OK. This board doesn't directly connect to earth in any other way and nor does the display PCB.

It was then that I spotted what could be causing the problem. While checking around the display PCB area, I noticed that an earth strap between the side panel and the front panel wasn't connected and was simply "floating". After I reconnected it, the fault disappeared and that's the way it's stayed for some two years now.

It turned out that the side panel had been vandalised and replaced some months before the original symptoms appeared. So it looks like the problem was due to interference after all but it's often difficult to know where to start looking in such cases.

The reluctant Miele

A bloke will go to any lengths to get out of washing-up duties and that's just what G. C. of The Gap, Qld did recently when his dishwasher failed. Here's how he eventually got it going again . . .

One morning about 18 months ago, I decided to unload our Miele G2220 dishwasher only to be met by an ominous "F84" message on its display. So what was this all about?

Searching the internet revealed that this was a "slide shutter positioning fault". Initially I had no idea what this meant. There were various fixes listed and they ranged from cleaning out the drain hose entry in the kitchen sink "S" trap to replacing the circulation pump at some huge cost but there didn't seem to be any obvious cure.

Some days the machine would complete its cycle without complaint, while at other times the dreaded "F84" fault would stop it dead in its tracks. Occasionally, F85 would be displayed and this indicated a "slide shutter signal change fault".

Although the machine was now seven years old, I felt it was too early for it to be retired and so I decided to try to repair it. I discovered that the slide shutter was in the circulation pump and it was controlled to alternately operate the middle spray arm for 30 seconds and then the top and bottom spray arms together for 30 seconds. When the circulation pump was initially operated, the middle spray arm was always selected. This arm was also selected when the detergent dispenser was opened later on in the cycle.

After hauling the machine outside to a covered area, I managed to extract the circulation pump but only after removing nine connectors, three earth wires and four hoses. A small 230VAC synchronous motor and associated gearbox was mounted on the side of the pump housing and this was obviously the slide shutter control motor.

Suspecting it to be faulty, I removed it and connected it to 230VAC but the highly-geared-down motor operated flawlessly. I then took a look inside its plastic housing and discovered that there was a crank from the motor pulley to a gear which oscillated to and fro. This in turn engaged another gear inside the pump which powered the slide shutter band.

Miele had made it easy to get the timing correct as one of the teeth was in fact a double tooth. The motor pulley was cam-shaped and activated a microswitch whose contacts closed momentarily once per cycle. The contact resistance of this switch was consistently low when measured.

Ruling out a fault with the slide shutter motor, I now looked very closely at its connector and also the one for the microswitch contacts. The former was quite corroded, so I replaced it with a pair of spade-type connectors. After re-assembling the machine, I connected it to a garden tap and did a couple of cycles without error so I was fairly confident that the problem had been fixed.

The dishwasher was subsequently re-installed in the kitchen and it then worked for the next 16 months without a single fault. But then the terrible "F84" code returned and progressively became more frequent.

This time, I decided to look at the control board in the top of the door. All the electrolytic capacitors tested OK and after re-soldering a couple of "crystalline-looking" joints, I put it back in the machine, feeling rather defeated. It didn't fix the problem and the machine soon got to the stage where it could not be used without displaying an "F84" or "F85" fault.

I hauled it back outside again and soon found that the spade connectors I had fitted quite some time ago had corroded quite significantly. This had occurred even though they were insulated connectors and had been wrapped with insulation tape. This time I crimped and soldered the connectors, covered them with heat-shrink tubing and then wrapped everything with self-amalgamating tape.

I was so confident that I had fixed it that I didn't bother testing the dish-

washer outside but simply re-installed it in the kitchen. However, on powering it up, I was soon greeted with the wretched F84 fault.

I dragged it back outside again and connected 230VAC directly to the slide shutter motor. With the appropriate hoses now removed from the pump body, I could observe the slide shutter opening and closing the various outlets on the pump housing. I could also measure the resistance at the microswitch.

It was all working perfectly so it was time to look elsewhere. After gaining access to the control board, I was able to measure from its connectors directly to the slide shutter motor and the microswitch contacts (Miele had conveniently left a diagram in a sealed plastic envelope beside the control board and this showed the board connectors and their interfaces. This saved having to use a cable tracer as all wires were white without stripes!).

One thing I noticed was that the cables flexed each every time the dishwasher door was opened. This made me wonder if a cable had fractured but after checking, this didn't seem to be the case.

At that stage, the only logical conclusion I could come to was that the fault lay in the control board. I then traced the tracks on the board from the microswitch contacts. One wire was connected to the supply via a resistor and the other to an input of the microprocessor, also via a resistor. I checked the tracks with an Ohmmeter but couldn't find any faults.

The slide shutter motor was fed with 230VAC via the contacts of a 12V relay. I removed this relay from the board, operated it from a 12V battery and checked its contact resistance. This was done many times and it appeared to operate perfectly.

In spite of this, I replaced it as a new relay was less than $6 and the original unit had done 150,000-plus operations. If the contacts on this relay failed to release, an F85 fault would be registered and so that was another good reason to replace it. Nevertheless, it was no surprise when an F84 code soon appeared when the machine was tested.

Further circuit tracing revealed that the microcontroller drove the relay via an MC1413D SOIC. This 16-pin device contains seven high-voltage, high-current Darlington transistor arrays and costs just 75 cents, so it was an easy decision (and an easy job) to replace it. There was continuity from the appropriate output of this chip to the relay coil and also from the input back to the microcontroller's relevant output pin.

Once again, I reinstalled the control board and nervously switched on. This time, it got well past the point at which the F84 error was usually displayed and it was all looking promising when suddenly the drain pump operated with "F70" being displayed on the screen.

Miele's fault code list said that this was a "float switch fault", indicating that the "waterproof system" had activated. In other words, the dishwasher was leaking like a sieve. To be honest, this fault wasn't entirely unexpected as I had somewhat foolishly re-used the rubber seal between the pump housing and the dishwasher sump. I had also re-used the large "O" ring in the slide shutter gearbox and this had been stretched, making re-fitting difficult.

It was soon evident that the 50mm "O" ring was leaking. As a result, I temporarily used a waste pipe square-section "O" ring so that I could test the machine before ordering the necessary parts from Miele. This time, a few seconds into the test, the machine stopped with an F24 error!

That was just about the last straw! Taking the machine to the local dump was beginning to look very attractive, especially when my wife dropped a bombshell to the effect that our washing machine had also developed a fault and wasn't spinning the clothes properly!

What on earth did F24 indicate? Further investigation revealed that the water heater is inside the plastic pump housing. This heater is operated via a 230VAC relay labelled "K" when a pressure switch is operated (the latter can only operate if the pump is full of water). So on start-up, the drain pump is operated for 18 seconds and then the control board looks for 230VAC on the contacts of the un-operated "K" relay (ie, via the un-operated pressure switch). If it sees 230VAC, it displays "F24", meaning that either the "K" relay contacts have welded together or there is severe leakage at mains potential.

This was all very interesting but what was the fault in my machine? I traced the heater cables to a large relay and removed the three connectors that were attached to it. None of its contact pairs were open circuit, so I removed the relay from its case and found that the latter was half full of water, obviously as a result of the leaking slide shutter gearbox "O" ring.

After cleaning the relay with contact and circuit board cleaner, I then found that the coil had gone open-circuit while I was drying it with a hairdryer. Closer examination showed corrosion on the coil.

Determined not to give up, I tried running the machine without the relay. I knew that it would flag an error when it could not heat the water in a given time but at least the machine would run for a while, or so I thought. Once again, the mischievous Miele outsmarted me, coming up with an F51 error quite early in it cycle when it couldn't detect the presence of the "K" relay.

I found that I could order the relay and the rubber circulation pump/sump seal but not the slide shutter gearbox "O" ring. The latter could only be obtained by purchasing the circulation pump without the electric motor for $295. I politely declined and purchased a couple of 50 x 3mm "O" rings from a bearing shop at $1 each.

After a few days, the Miele parts arrived and after putting it back together, I gingerly switched the machine on. Fortunately, it was an anti-climax and for the first time for several weeks, it operated free of fault codes. What's more, it has continued in this happy state for some time now.

So it was all a bit of a saga, with most of the problems caused by my re-use of the seal and "O" ring and, of course, my inexperience with dishwasher repairs. In the end, it was a relief to have the unit back in service, as it relieves me of my washing-up duties! SC

6-Digit Retro Nixie Clock Mk.2

. . . now with optional GPS time

This revised 6-digit Nixie clock includes features such as GPS-locked time, date display, 7-day alarm, auto-dimming, 12/24 hour time and optional leading zero blanking. Having described the circuit and software operation in Pt.1 last month, this time we describe how to put the kit together.

Pt.2: By Nicholas Vinen

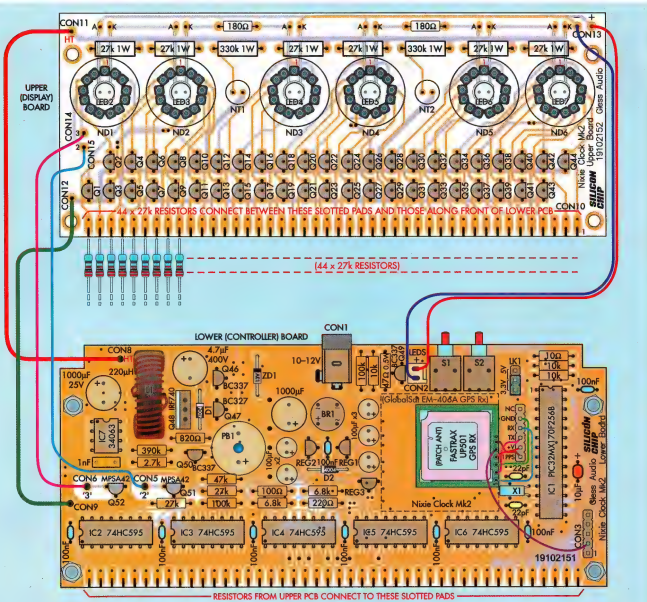


Fig.3: follow this PCB layout and wiring diagram to build the Nixie Clock. The sockets on the upper board are made from snapped sections of socket strip – note how they are arranged. The GPS module connections shown are for the Fastrax UP501; other modules will require different connections so refer to Fig.5 or the appropriate data sheet and observe the connector pin labelling. Once the two boards are joined by four spacers, the six wires between them can be connected and the 44 x 27kΩ resistors soldered into the slots along the front.

THE NIXIE CLOCK MK.2 comes exclusively as a kit from Gless Audio and there are various options, eg, whether or not the case is included. Regardless of which kit you choose, you will need to start by building the two boards and joining them together.

Start by checking the slots along the front of the two double-sided boards. Due to the way the slots are made, some may be partially blocked with copper fragments. If so, use a small piece of stiff wire to clear them out.

Now fit the small (0.25W and 0.5W) resistors on both boards. Use parts layout diagram Fig.3 and the resistor colour code table (Table 1) to guide you. It's a good idea to measure the resistors with a DMM before fitting them as resistor colour code bands can be hard to read.

You will be left with a number of 27kΩ resistors. While two of these are fitted to the lower board, the rest will later be soldered between the two boards, so set them aside for now.

Finishing the upper PCB

Note that the upper board shown in Fig.3 has been changed slightly from the original and it's possible you could get an earlier revision in the kit (the same one used in our photos). You can ignore the differences as they don't affect operation in the slightest.

Proceed to solder the eight 1W resistors in place on the upper board, as shown in Fig.3. Then, carefully snap the two 40-pin socket strips into 36 sections with two pins and then snap six single pins off the remaining strips. These form the Nixie tube sockets, arranged as shown in Fig.3.

Check after soldering that each section is sitting right down on the PCB.

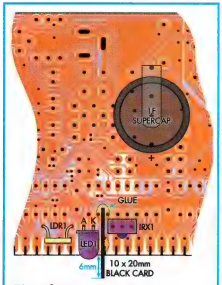
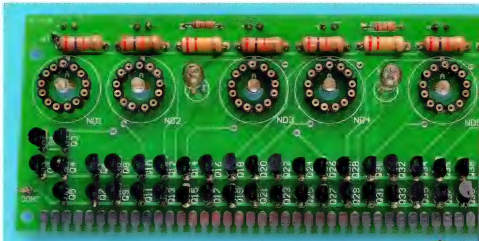


Fig.4: four components are soldered to the underside of the lower PCB as shown here. Note that two different sets of pads are provided for the supercap to suit different brands but the capacitor supplied with the kit is likely to use the outer pair. The small piece of black card is glued into place once all four of the parts shown have been fitted.



The top PCB carries the six Nixie tube sockets (see text), the two Neon lamps, the 44 segment-driver transistors and the six blue LEDs which illuminate the bases of the Nixie tubes. Check that all parts are correctly seated and orientated before soldering their leads and note that the six LEDs are mounted on the bottom of the PCB (see photo on facing page).

The 44 high-voltage transistors can be installed next. These are all the same type. MPSA42 types will probably be supplied but MPSA44 and 2N6517 are valid alternatives. Note that there are several other similar-looking devices in the kit so put those aside first.

Fit all 44 transistors on the upper board with the same orientation, ie, flat side to the right as shown in Fig.3. You will need to crank the leads out using small pliers to suit the pad spacings on the PCB. Make sure that they are all pushed down fully before soldering – if they aren't, when you go to fit the perspex cover later, you will find that it can't be screwed down properly.

Next come the six blue LEDs. These poke up through a hole in the middle of each socket but are actually fitted on the underside of the board and soldered to pads near the top edge.

Start by bending one the LED's leads down by 90° about 3mm from its body, at the same time ensuring that its polarity will be correct when it is mounted in position (see Fig.3). That done, cut a couple of lengths of small diameter heatshrink tubing and slip them over the leads so that they are insulated all the way from the LED's lens until just before they reach its two solder pads. It's then just a matter of bending the ends of the leads up to pass through these pads before shrinking the tubing down and soldering the leads in place.

Repeat this procedure for the other five LEDs, checking the orientation in each case. The photo on the facing page shows the details.

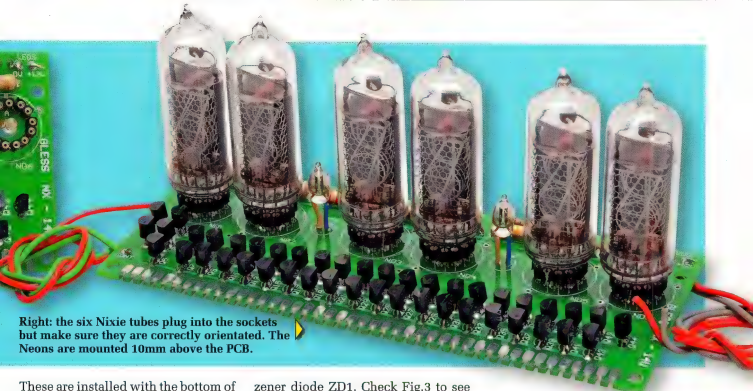
Finally, fit the two Neon lamps.

Parts List Additions

In the parts list last month, we left out the 28-pin DIL socket for the microcontroller (IC1). Also, the case is held together with 16 self-tapping screws rather than the 12 specified and it also includes four stick-on feet.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	390kΩ	orange white yellow brown	orange white black orange brown
❑	2	220kΩ	red red yellow brown	red red black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	6	27kΩ	red violet orange brown	red violet black red brown
❑	3	10kΩ	brown black orange brown	brown black black red brown
❑	2	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	1	2.7kΩ	red violet red brown	red violet black brown brown
❑	1	820Ω	grey red brown brown	grey red black black brown
❑	1	220Ω	red red brown brown	red red black black brown
❑	2	180Ω	brown grey brown brown	brown grey black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	47Ω	yellow violet black brown	yellow violet black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown



Right: the six Nixie tubes plug into the sockets but make sure they are correctly orientated. The Neons are mounted 10mm above the PCB.

These are installed with the bottom of the glass envelopes 10mm above the top of the PCB and with the exposed leads covered with heatshrink tubing. The critical thing is that the leads are perpendicular to the PCB and that the two lamps are at the same height. These form the hour/minute and minute/second separators.

If you cut the heatshrink sections all to the same length (around 11mm) prior to shrinking and keep them butted up against the underside of the lamps, these will then form natural spacers to allow you to get a consistent stand-off height between the two.

Assembling the lower PCB

Continue the lower PCB assembly by installing diodes D1 & D2 and zener diode ZD1. Check Fig.3 to see which goes where as there are three different types. Make sure that they are orientated as shown.

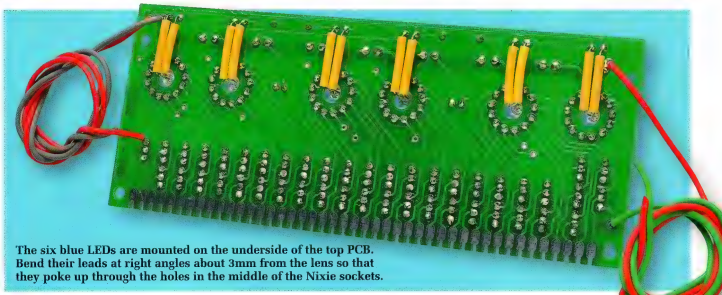
After that, it's a good idea to fit the four PCB pins for CON5, CON6, CON8 & CON9. This is because they are a tight fit and you will probably need to hammer them in before soldering. The tightness is so they don't fall out when you flip the board over to solder them.

Now mount the IC socket for microcontroller IC1, then install IC2-IC6 and REG1 which do not require sockets. Having said that, you may be supplied sockets for IC2-IC6 in which case you can use them; it does eliminate the possibility of accidentally soldering an IC in backwards which can be very difficult to fix!

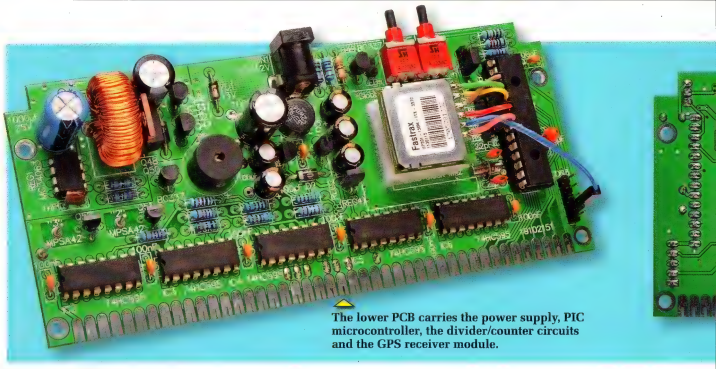
Regardless, be careful with the orientation – ensure that the notched end of the IC or socket goes to the top (IC1, REG1) or lefthand (ICs2-6) end of the PCB. In each case, solder two diagonal pins, then make sure the device is flat on the board and pushed down all the way before soldering the other pins.

Fit crystal X1 next. Bend its leads as shown but make sure they don't touch its case. You can use a component lead off-cut bent into a "U" shape and soldered to pads on either side of the can to hold the crystal down onto the board as the thin leads can be quite fragile.

The two pushbuttons can go in next, pushed fully down onto the PCB. Follow with bridge rectifier BR1 (watch its



The six blue LEDs are mounted on the underside of the top PCB. Bend their leads at right angles about 3mm from the lens so that they poke up through the holes in the middle of the Nixie sockets.



The lower PCB carries the power supply, PIC microcontroller, the divider/counter circuits and the GPS receiver module.

orientation) and the remaining TO-92 package devices, ie, Q46, Q47, Q49-Q52 and REG2-REG4. These involve three different transistor types and two different regulator types so don't get them mixed up; refer to Fig.3 to see which type goes where. As before, you will need to crank the leads out before fitting them.

Now flip the board over and fit the parts which go on the underside: IRX1, LED1 and LDR1. Fig.4 shows the details. Note that LED1's and LDR1's leads are bent down by 90° just behind the main body of each part. They are then fitted so that they hover just under the PCB (but not touching it). IRX1 should be pushed all the way down onto the PCB before being soldered.

IRX1, LDR1 and LED1 are all orientated so that their lenses face the adjacent edge of the PCB. Make sure LED1's anode (longer lead) goes through the hole marked "A". The orientation of the LDR is not important. Leave off the supercap for now.

As shown in Fig.4, you also need to cut and glue a piece of black card between LED1 and IRX1. This is to minimise the amount of light from the LED which reflects off the inside of the front panel of the case and straight back onto IRX1.

Cut a 10 x 20mm piece of card out and glue it as shown in Fig.4. We used hot-melt glue but neutral-cure silicone sealant would be a better choice.

You can check that the card is correctly placed by temporarily fitting the short spacers to the underside of the PCB and dropping it into the case. The card should sit on (or hover just above) the base and should also be in contact with the front side of the case, or very nearly so. If it's pressing on the case you can trim it for a better fit.

Now go back to the top side of the board and install the 11 ceramic/plastic-film capacitors, followed by the seven electrolytic capacitors in the locations shown in Fig.3. Note that the electros are polarised.

The electrolytics all go in the same way except for the two near the upper-lefthand corner of the PCB, which go in the other way around. Just be sure to orientate them as shown on Fig.3.

The remaining tantalum/SMD ceramic capacitors can go in now. If you're supplied with a tantalum, this is polarised just like the aluminium electrolytics and will have a plus symbol printed on it. This goes towards the top of the board.

If using an SMD ceramic instead, solder it to the pads on the top of the board; the orientation doesn't matter.

Now fit the pin headers for LK1, CON2, CON6 and optionally CON5. Follow with DC socket CON1, then install the piezo buzzer (PB1) with its positive terminal towards the bottom of the PCB – see Fig.3. If it has a protective sticker on top, peel it off now.

Time Zone Enhancements

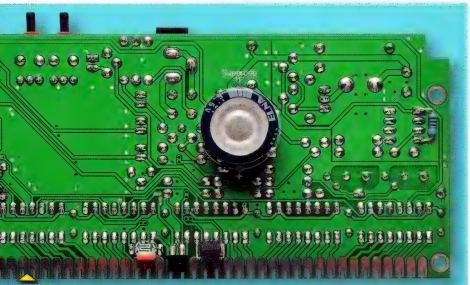
In the article last month, we gave a list of regions where the time zone and daylight savings rules would be automatically determined. Since then, we have been able to add much more time zone data. As a result of the now near-global coverage, the unit should be able to determine the correct time zone just about anywhere on Earth. If you're reading this from McMurdo station, you may be out of luck though!

The resulting compressed time zone database is just shy of 200KB, so it comfortably fits in the PIC32's 256KB flash.

We realise that few constructors will require global coverage as most will live in Australia, New Zealand with maybe a few in the UK, Canada and the USA. So you may wonder why we bothered doing the extra work. The reason is that a global time zone database that fits in a microcontroller seems like a useful thing in general and some readers may wish to use it in their own projects.

As far as we know, this is the first publicly available database (and codebase) to offer global coverage in such a compact package. So by releasing the source code for this project, we've made it much easier for anybody wanting to build a truly global GPS clock using a low-cost, compact microcontroller.

If you're interested, download the source code from our website (www.siliconchip.com.au) and peruse it. The time zone data and handling functions should be easy to bring into your own software if you are familiar with the C language.



This view shows how the LDR1, LED1, infrared receiver IRX1 & the supercap are installed on the underside of the upper PCB.

You can now mount toroidal inductor L1. Ideally it should be glued to the PCB with some silicone sealant but the board likely won't be subject to much vibration so you can get away without doing this.

The last part to be installed on the top of the PCB is high-voltage Mosfet Q48. This is soldered in place with its metal tab facing inductor L1.

All that's left now is to mount the super capacitor on the underside of the PCB. There are two sets of holes to suit different types of capacitors; most likely the supplied part will fit the most widely spaced pads (see Fig.4). Make sure the supercap is installed with the correct polarity – its positive lead should be marked and this goes into the pad near ZD1.

Initial power tests

Before going any further, it's a good idea to apply power and check some voltages. If you have a bench supply, set it to 12V DC 500mA, otherwise use the plugpack. **Make sure the board is on a non-conductive surface and keep well clear of the upper-left section while it is powered up and for one minute afterwards. This area of the board runs at 180V DC and it does bite – trust us!**

The current drain will be a few hundred milliamps initially as the supercap charges but it should eventually drop to a few tens of milliamps, most of this being the quiescent current of the high-voltage boost DC/DC converter.

Check the 3.3V and 5V pins on LK1, using the PCB pin near the lower-left corner of the board as a ground reference. These should both be close to their nominal voltages. Also, check for 3.3V at pin 2 of CON3 at lower-right. Now without touching any nearby components, check the voltage at the upper-left PCB pin, just to the left of L1. This should be close to 180V DC.

Switch off and wait one minute for the HV capacitor to discharge. Measure the high voltage pin again, as explained above and ensure it's below 20V before proceeding.

Assuming the voltages are all OK, you can finish the construction. Otherwise, check for correct component placement and orientation and for good solder joints, then repeat the tests.

Fitting the GPS module

If you're building the GPS-locked version of the clock, it's basically just a matter of running five or six wires from the module to CON7 and then attaching the module to the PCB.

First, identify the connections on your module. Connections for a few common types of GPS receiver are shown in Fig.5. Be careful to check which is pin 1 since the pin ordering will depend on the orientation of the module, ie, if you flip it over, the wiring order will be reversed.

If your module is not shown in Fig.5, refer to its data sheet. If there is a BOOT or ENA (enable) pin, determine whether it needs to be left floating or connected to GND or V_{DD} for normal operation. If there is a V_{DD_B} pin, check that the 3.3V back-up supply at pin 2 of CON3 will be suitable; in most cases, it will be. The module's RX terminal goes to the pin labelled RX (pin 2), ie, this is labelled for the module and not for the micro.

Most modules will either be supplied with a cable that plugs into a small onboard header or else will have a row of solder pads. If it came with a cable, cut it short, to about 22mm and strip a couple of millimetres of insulation off the end of each wire before tinning it. Otherwise, you will need to cut a similar length of ribbon cable and solder one end to the row of pads, with bare tinned wires at the other end. If there is a V_{DD_B} wire, make it substantially longer than the others, at around 50mm, so it can reach pin 2 of CON3.

There are two options for making the connections. You can either solder the bare wires directly to the pins of CON7 or you can attach a pin header plug (or cut up a cable with a header already attached). A plug obviously

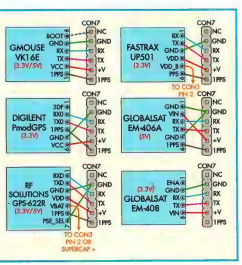
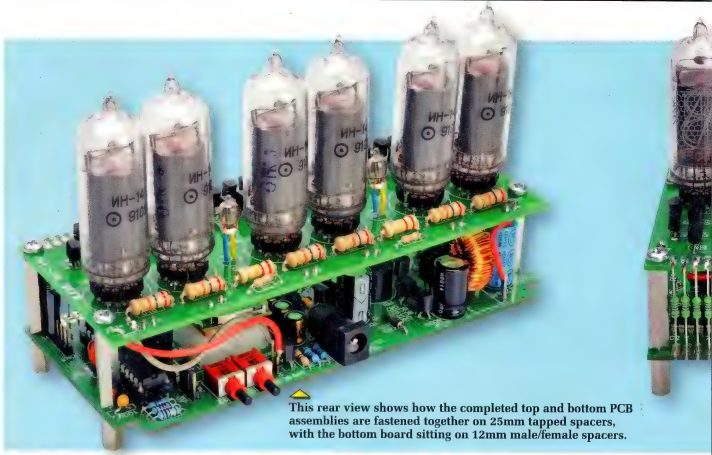


Fig.5: how to wire up various GPS modules. Take care with the pin 1 orientation and note that the wiring shown for the UP501 is different from that shown in Fig.3. That's because we're showing the UP501 with its antenna facing down in this diagram but facing up in Fig.3. Also note that VK16E's BOOT pin may be left unconnected and the GPS-622R's VBAT pin can go to either CON3 (as for the UP501) or directly to the supercap positive terminal, which would give a longer ephemera retention time.



This rear view shows how the completed top and bottom PCB assemblies are fastened together on 25mm tapped spacers, with the bottom board sitting on 12mm male/female spacers.

Adjusting For Accurate Timekeeping Without GPS

Assuming a relatively stable ambient temperature, the unit can be adjusted to be out by less than one second per month. The easiest way to do this is as follows:

(1) Set the time using an accurate reference such as the speaking clock service (phone 1194 in Australia or 0900 45678 in New Zealand). Make a note of the date that you do this. You don't have to set the clock to be precisely correct, as long as you know how much it's off by. If it isn't precise, make a note of the number of seconds error. For example, if you've set the clock to say 09:00:00 at 9:00:02am on March 15th, the error is -2 seconds.

(2) Leave the clock for some time – a week is sufficient but longer is better.

(3) Using the same accurate time source you used earlier, compare the time on your clock to this more accurate time source. So, for example, let's say your clock reads 10:08:33am but the speaking clock service says it's 10:08:12am on March 23rd. The error is now -21 seconds. Make a note of this and also of the current date.

(4) Subtract the first error from the second error. In this case, the result is -19 seconds. If the time was set precisely during the first step, this will not affect the error noted in step three above.

(5) Determine the number of days that have passed between steps one and three. In our example, it's eight days (23 -15).

(6) Multiply the error from step four by 1024, then divide by the number of days from step five and divide again by 45. The result in this case is -21 x 1024 ÷ 8 ÷ 45 = -59.7 which we round to -60.

(7) Go into crystal frequency trim mode (see panel on control interface) and add the number calculated above to the reading. So, in this case, if the current reading was 500, you would need to adjust it to give 440 instead. Save the changes and that should cancel out most or all of the error.

(8) If you notice over many weeks or months that the clock is slowly gaining or losing time, adjust the trim value in single steps. Make it higher if the clock is falling behind or lower if the clock is going too fast.

makes it easier to remove the module later, however this is not normally required and it's certainly quicker to solder them direct.

In theory, the GPS module should be orientated with its ceramic patch antenna facing up. However, we experimented with both orientations and found that it made little difference to sensitivity.

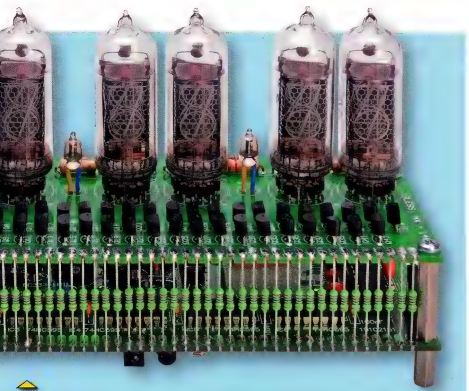
If soldering the wires directly to CON7, mount the module first. Otherwise, once the plug has been wired up, plug it in and then mount the module. Smaller modules such as the Fastrax UP501, GlobalSat EM-406A and VK-16E can be fitted directly on top of the PCB using some double-sided tape.

However, in practice, it's preferable for them to be further away from the ground plane, so it's better to attach them using a non-conductive spacer. Larger modules will require a spacer to clear surrounding components.

The spacer can be made from plastic or a non-conductive type of stiff foam and attached to the board and the module itself using double-sided tape. Use multiple layers of plastic if necessary to create a thick enough spacer.

We used polyethylene foam since we happened to have some handy but a more rigid material is better.

Once the GPS module is in place,



Above: the 44 x 27kΩ resistors are strung between the two PCBs and soldered to slotted solder pads along the front edges. Make sure that the resistor leads are straight and use a ruler to ensure that they line up neatly (see text).

fit the shorting block to LK1 to set the required supply voltage (3.3V or 5V).

Joining the two boards

Now plug IC1 into its socket. You will probably need to straighten its pins first. Make sure that the pins all go into the socket. Also, plug in the other ICs if using sockets for them as well.

The next step is to cut two 60mm lengths and four 40mm lengths of mains-rated medium-duty hook-up wire. Strip and tin both ends, then solder one end of each to each of CON11-CON15 from the underside of the upper PCB. The two longer wires are for CON13.

Now place the upper board upside-down behind the lower board (right-side up) and solder the wires to the PCB pins (CON5, CON6, CON8 & CON9) and 2-pin header (CON2) on the lower board as shown in Fig.3. It's easiest to start at the back and work your way to the front of the lower board. Make sure the wires to CON2 aren't reversed or the LEDs won't light up.

Having done that, fit a 12mm male/female tapped spacer to one of the mounting holes on the lower board from the underside, then attach a 25mm tapped spacer on the top side. Do this up tight, then repeat for the other three mounting holes. You can then fasten the two boards together using four M3 x 6mm, pan-head screws. Do these up firmly and make sure the six wires are still connected at both ends and neatly tucked away.

The next step is to fit the 44 27kΩ resistors into the slots along the front of both boards. It's important that the bodies of these resistors are lined up carefully so that the finished clock looks neat. The following procedure is recommended. Try to avoid bending the resistor leads when removing them from the strip they are supplied on.

Take two resistors with nice, straight leads and insert them into the pair of slots at the far left and far right ends of the boards. Next, use a small ruler to measure the distance between each resistor's body and the top and bottom boards and move the resistors up and down until those distances are equal. Solder one end of each device, then check that the each resistor is still centred properly before soldering its other end.

That done, insert another resistor between two slots near the middle (make sure the slots correspond!) and place the ruler horizontally so that it lines up with the bottom of the resistor bodies at either end. Adjust the middle resistor so it too is aligned with the ruler and solder it in place using the same method as before.

Now continue by placing two more resistors between the three already soldered in, and keep "bisecting" in this manner until all the resistors are in place. This method gives you the best chance of getting them all to line up without the gaps increasing or decreasing as you go.

Once they're all in place go back over all the solder joints and make sure they have sufficient solder and have flowed properly before trimming off any excess lead length remaining.

More testing

The Nixie tubes can now be unpacked and plugged into their sockets. Before plugging them in, you will need to remove the plastic spacer and carefully trim the leads to exactly 5mm long, measured from the glass base of the tube. Make sure the leads are all straight, then gently place one tube on top of one of the sockets with each lead sitting in the cup of its socket pin.

Now slowly push the tube into its socket. If any of the pins are not properly in the socket or if any starts to bend during insertion, remove the tube and fix that pin, then try again. It should go in with gentle pressure.

Fit the other five tubes in a similar manner, then make sure the whole assembly is clear of any conductive items such as loose bits of wire and solder. With the plugpack disconnected from the mains, plug it into CON1, then keep yourself clear of the board assembly while powering it up.

Be careful during testing: as stated, the HT supply is around 180V DC and it can give you a nasty shock if you come into contact with it! Don't touch or work on the unit when the plugpack is connected.

In addition, wait 15 seconds for the 10µF 250V capacitor to discharge after switch off before touching the unit. It should be safe once the Neon lamps have gone out but if in doubt, measure the HT voltage rail.

The Nixie Clock performs a display test initially, so you should see all six zero segments light up, followed by one, two, three etc. **Note that the first, third and fifth tubes will only display digits up to three, five and five respectively so don't be concerned that they do not light when the other tubes are showing six, seven, eight etc.**

The unit should also emit a short beep briefly after power is applied,

Using The Control Interface

The clock is set up and controlled using the two rear-mounted pushbuttons and the front proximity sensor. We refer to the pushbuttons as "left button" and "right button"; this is the orientation when the digits of the clock are facing you. Below, we talk about short and long presses. A short press is under one second (typically, 250-500ms) while a long press is for more than one second. Some actions require the buttons to be pressed simultaneously.

A number of settings are stored in the microcontroller's flash memory so they are effectively permanent, even if power is lost for long periods. These are: LED status (blue LEDs on/off), 12/24 hour time setting, leading zero blanking setting, timing crystal trim value, alarm time and days, time zone (if a GPS module is fitted) and LED/Nixie dimming settings.

The various actions that can be performed using the buttons are:

- **To turn blue LEDs on/off:** press both buttons, then release simultaneously after a short duration (around half a second).
- **To set time and/or date (no GPS fitted):** long press left button. Time is frozen and one digit flashes. Short press left button to increment digit, short press right button to move to next digit. To switch between setting time and date, long press right button. When finished setting, long press left button.
- **To set the time zone (GPS fitted):** long press left button. Flashing "00" indicates automatic time zone & daylight saving mode. Short press left/right buttons to change to manual mode and set time zone offset in 15-minute intervals. With time zone set manually, daylight saving is disabled. Long press left button to save changes, long press right button to abort. To go back to automatic TZ/DST, go into time zone setting mode and press left/right button until flashing "00" is displayed again.
- **To switch between 12-hour time and 24-hour time:** go into time set or time zone set mode (long press left button), then hold down both buttons for at least one second and release simultaneously.
- **To show the date:** short press left button or briefly place your hand close to the proximity sensor at the lower front of the unit (within a few centimetres of the case).
- **To set alarm:** long press right button. Set alarm time using the same procedure as outlined for setting the time above. By default, alarm sounds during week days only. To change, long press right button. Days are shown as 0123456 with 0 = Sunday, 1 = Monday, etc. Days for which alarm is enabled are lit, disabled days are off. Short press left button to toggle alarm setting for current (flashing/pulsing) day. Short press right button to move to the next day. Long press right button to return to setting alarm time; long press left button in either mode to save settings and enable alarm.
- **To show alarm time:** short press right button. Alarm time is shown for 10 seconds, then it goes back to displaying the current time. If alarm is on, display during this time is solid, otherwise it flashes.
- **To turn alarm on/off:** show alarm time as described above, then short press left button to toggle alarm on/off.
- **To cancel/snooze alarm:** trigger proximity sensor (as described above for date display) for 10-minute snooze. Short press either button to cancel alarm.
- **To trim out crystal frequency error (not required when GPS module fitted):** hold down both buttons for at least one second, then release simultaneously. Adjustment is initially 500; higher values (up to 999) make clock run faster, lower values make it run slower. Short press left and right buttons to reduce/increase trim value. Long press left button to save changes, long press right button to abort. See accompanying panel for how to determine the correct value.
- **To enable or disable leading zero blanking (generally used in 12-hour time mode):** go into crystal trim mode (see above), then after releasing buttons, hold down both buttons again for at least one second and release simultaneously. By default, leading zero blanking is not enabled, so this will enable it. Use the same procedure to turn it off again.
- **To enable or adjust auto-dimming:** both the Nixie tubes and the blue LEDs can be set to automatically dim as the ambient light level drops (as sensed by the onboard LDR). There is a dimming factor value for each. If set to zero, they will always operate at full brightness. For numbers greater than zero, larger numbers mean faster dimming as the ambient light level drops, up to a maximum value of 20, with a default value of eight. To set the LED dim factor, hold down the right button for at least one second, then press the left button and quickly release both. The left and right buttons are then used to change the value with a long press of the left button to exit. Setting the Nixie tube brightness is identical but reverse the initial long/short button presses (ie, hold down the left button then briefly press left).

verifying that the piezo buzzer works.

Having gone through the digit test, you will then see a display of "00.00.00" with the first digit flashing, indicating that the time has not yet been set. Check that the blue LEDs are lit.

If anything goes wrong, switch off and check the assembly for faults. If one or more segments are not lighting, first check that the tube is inserted properly in the socket and that the resistors along the front of the unit are all soldered properly. Otherwise, it could be a suspect solder joint on one of the ICs.

If you don't get any display, that suggests a problem with IC1 or its associated crystal oscillator. Nothing will function if the oscillator isn't working. If the Neon lamps don't light, that suggests a problem with the boost generator or wiring as they are permanently wired across the HV rail.

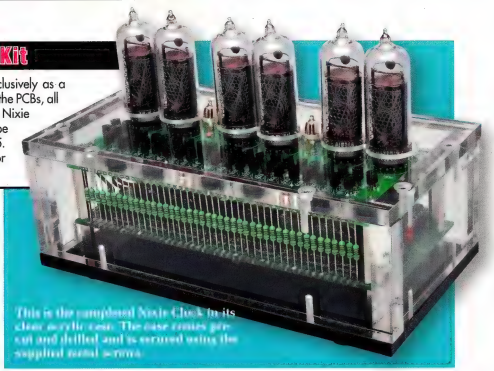
If it checks out, switch off and wait 15 seconds after the Neons go out before touching the board assembly.

Putting the case together

The case is made from six pieces of acrylic, one black and five clear, held

Where To Buy A Kit

The Nixie Clock Mk2 will be available exclusively as a complete kit from Gless Audio. This includes the PCBs, all components, a programmed microcontroller, Nixie tubes and the case hardware. Kits should be available late February/early March 2015. Contact Gless Audio on 0403 055 374 or email glesstron@msn.com



This is the completed Nixie Clock in its clear acrylic case. The case comes precut and drilled and is secured using the supplied metal screws.

together with 16 self-tapping screws which go into pre-drilled holes. Start by attaching the thicker clear front and side panels to the base panel using six of the supplied self-tapping screws. Next, attach the thinner clear rear panel to the sides with four more screws.

You can now affix the feet to the base. Position them horizontally just within the PCB mounting holes, 5mm from the front edge of the base and 10mm from the rear edge.

Now temporarily remove the Nixie tubes from the PCB assembly before lowering it into the case, positioned towards the front. Once it's resting on the base, slide it back so that the pushbuttons pop through the routed access slot at the rear. You can then secure the whole thing in place using four M3 pan-head screws up through the mounting holes in the base. Do them up nice and tight.

Now fit the lid using the six remaining self-tapping screws. Once it's in place, you can carefully plug the Nixie tubes back in.

Final testing & operation

With everything now inside the case, re-apply power. If you've fitted a GPS module, the display brightness will vary in a pulsating fashion until a position fix has been obtained. If you don't get a fix after 30 minutes or so, try moving the unit to a less obstructed position, such as near a window. If the fix is lost, the unit will switch over to using its own crystal and the brightness will pulsate until it again has a reliable GPS fix.

If you aren't using a GPS module and the time has not yet been set, refer to the panel titled "Using the Control Interface" for instruction on using the two rear panel pushbuttons to set the time. When first powered up, the unit is already in time set mode, so it isn't necessary to hold down the lefthand button to get into that mode. Don't forget to set the date, too.

Once that's done, you can check the operation of the proximity sensor. We've made it relatively insensitive to prevent false triggering so you will need to place your hand up close to the front of the unit, possibly touching it. If nothing happens, try moving it closer to the sensor. Once it's triggered, you should see the display change to show the date and then go back to time after 10 seconds.

You can now set up the various preferences to your liking. Refer to the instructions in the accompanying panel for turning the LEDs on/off, changing between 12/24 hour time and enabling leading zero blanking, if desired. If using the crystal for timekeeping (ie, no GPS) you can also start the calibration procedure as explained in that panel and there are also instructions there for setting the alarm if required.

Note that the alarm can be put into a 10-minute snooze using the proximity sensor but a press of either one of the rear panel buttons is required to actually shut it off when it sounds. SC

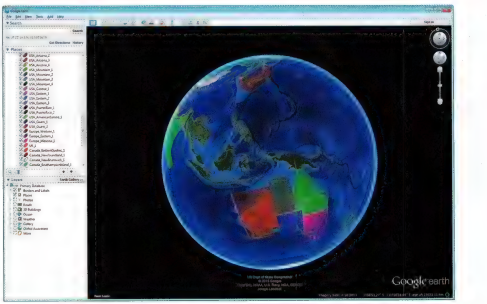


Fig.6: a Google Earth view showing some of the time zone regions used to calculate local time. These shapes have been simplified as much as possible, to save flash memory storage space, without compromising the accuracy of determining the correct zone for any latitude/longitude on land. For example, where they overlap, only the border of the time zone analysed first has to be accurate as areas within this zone are excluded before the latter zone is checked.

Modifying the Currawong Valve Amplifier

... is it worthwhile?

By Allan Linton-Smith & Leo Simpson

While the Currawong amplifier has created a great deal of interest, some readers would like to see it with improved frequency response, better output transformers, more expensive valves and so on. We have investigated a number of these possibilities and you can judge for yourself whether all or any of the modifications discussed are worthwhile.

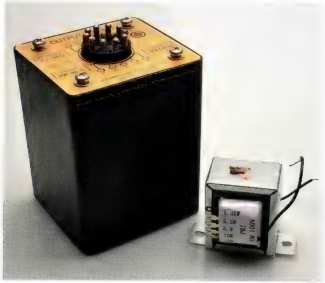
MOST READERS would regard the output transformers we used as looking physically puny compared to the much larger transformers fitted to valve amplifiers in the "olden days" and we would have to agree. So could bigger and better output transformers improve the performance? Possibly.

Before we had a look at that topic we had to address a query about the low-frequency response of the Currawong. As depicted in the graph of Fig.5 on page 38 of the November 2014 issue, the frequency response had a slight upturn at around 20Hz. Some people blamed this on the relatively small 100µF capacitors at the cathodes of the 6L6 output valves.

These supposedly did not allow sufficient decoupling at the lowest frequencies and the gain climbed slightly as a result. We did not agree with this contention for the following reason: increasing the cathode bypass capacitors will actually increase the low frequency open-loop gain but the effect of negative feedback will be to negate this anyway, and it will therefore have negligible effect.

Thus, we ran the frequency response test with an 8-ohm load again and compared the response with 100µF and 200µF capacitors (ie, with another 100µF in parallel) bypassing the 330Ω cathode resistors. Fig.1 shows the results and as expected, there is negligible difference in the two curves.

By the way, these curves are even flatter than those originally published in the November 2014 issue and we can only put this down to a slightly different valve line-up and wiring layout in the final prototype of the amplifier. We should also point out that, as in any



The Hashimoto HW-40-5 is much larger, heavier and more expensive than the Altronics M1115 line transformer. While its frequency response is flatter above 3W, the M1115 actually provides substantially lower distortion over most of its frequency range. This is likely due to its use of grain-orientated steel in the core

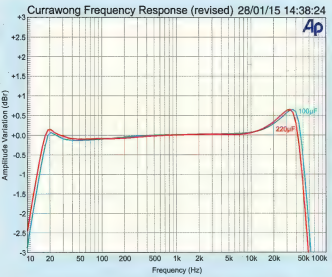


Fig.1: the Currawong frequency response as designed (blue) and with extra output stage cathode resistor bypass capacitance (red).

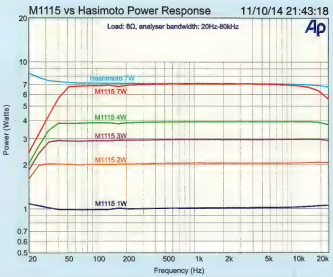


Fig.2: a comparison of the power response of the M1115 and Hashimoto transformers in the Currawong at various power levels.

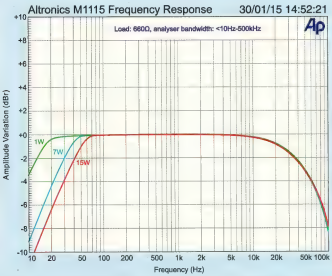


Fig.3: frequency response of the M1115 transformer operated open loop into a 660Ω resistive load. The load resistance gives 15W at its design output voltage of 100V.

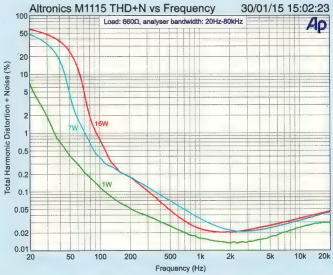


Fig.4: distortion of the M1115 transformer with the same set-up as in Fig.3. The distortion is quite low at 1W but increases at higher power levels and lower frequencies.

typical high-performance valve amplifier, the Currawong needs to run for at least half an hour before it produces the best performance.

Now to the question of the output transformer. A number of readers have pointed out that we should have published power response curves for the Currawong as these would soon throw up the deficiencies of the Altronics line transformer.

Hence we have prepared a series of power response curves and compared these to a highly regarded substitute transformer, the Hashimoto HW-40-5, made by Hashimoto Electric Ltd in Tokyo, Japan (available at more than US$700 for a pair). The frequency response claimed by the manufacturer is flat from 10Hz-60kHz ±0.1dB and it has an input impedance matched specifically for 6L6 valves of 5kΩ and output taps at 4Ω, 8Ω and 16Ω. It is suitable for amplifier powers up to 40W.

These transformers weigh 2.4kg each and are far too big and heavy to be mounted on the Currawong PCB, so they were externally mounted with longer leads.

Fig.2 shows a number of power response curves run with the Altronics transformer and one with the Hashimoto transformer at an output power of 7W into an 8-ohm load. Looking at the curves, the Altronics transformer does lack bass power at higher levels but is quite adequate up to about 3W RMS whereas the Hashimoto transformer has a flat power response down to below 20Hz.

The Hashimoto transformer was also tested for frequency response at various power levels up to 20W without negative feedback. Under this condition, the Hashimoto performs much better than the Altronics unit, as would be expected. Given that result, you might expect that the Hashimoto would produce significantly less harmonic distortion when feedback is applied (as in the normal Currawong

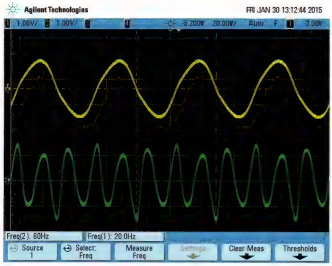


Fig.5: distortion from the Currawong with M1115 output transformers driving an 8Ω load at 20Hz & 1W. The residual is largely third harmonic and while the waveform distortion is clearly visible, it's still somewhat sinusoidal.

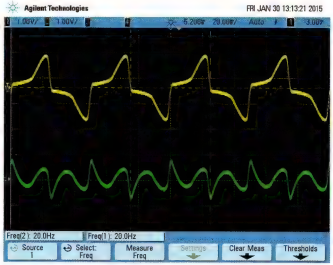


Fig.6: same as for Fig.6 but at 4W. It certainly doesn't look like a sinewave any more! The global feedback is applying maximum bias to try to correct the waveform but the transformer is saturated and it simply isn't possible.

configuration) but surprise, surprise, it turned out that the THD+N at 1W was higher than the cheaper transformer, as shown in Fig.7.

The negative feedback in the Currawong circuit is quite high for a valve amplifier and this will linearise the response and reduce harmonic distortion in the smaller transformer. Hence, the negative feedback was reduced to zero to see if the Hashimoto could do with less and therefore produce more power. It did and the best we could squeeze out of it was 20W but the harmonic distortion was a whopping 20% at 1kHz (with zero feedback).

Subjective listening tests

Subjective listening tests proved that the Hashimoto is a very good transformer but at more than 40 times the price of the Altronics M1115, it really is only marginally better. Of course, both transformers could deliver more power if the Currawong amplifier was run with much higher power supply rails and the circuit bias modified to suit.

However, the cheaper transformer would still be deficient in power response at the low frequency end, simply because its core is not big enough. To illustrate just how good (or bad, depending on your viewpoint), we decided to do a number of tests on the Altronics M1115 transformer when driven by a high-quality solid-state amplifier. In this case, the amplifier was connected to the primary winding and the transformer was used in step-up mode, as a 100V line transformer.

The secondary winding was loaded with a 660Ω 15W resistor (three 220Ω 5W resistors in series). In this mode, the transformer delivers 15W.

Fig.3 shows its frequency response at power levels of 1W, 7W & 15W. As can be seen, it's pretty good at 1W and obviously somewhat deficient at the low-frequency end when driven at 7W or 15W. This is due to core saturation.

The equivalent THD+N curves in Fig.4 reinforce the story and you can see that harmonic distortion rises drastically at the lower frequencies and particularly at high power levels.

To further demonstrate how transformer core saturation affects the low-frequency response, have a look at the scope grabs of Fig.5 & Fig.6. Fig.5 shows a 20Hz signal at 1W with the upper (yellow) trace being the transformer output while the lower (green) trace is the harmonic distortion; predominantly third harmonic at 60Hz.

Fig.6 is significantly worse with a 20Hz signal at 7W. Here the output of the transformer is running well into saturation and the harmonic distortion waveform is quite a bit worse, with more higher-order harmonics. At higher power levels, the story is similar with the distortion climbing to over 60%, as can seen from Fig.4.

Now let's consider the low-frequency power response and harmonic distortion of the Currawong amplifier. This demonstrates the miracle of negative feedback. Without negative feedback applied in the Currawong amplifier circuit, the performance is pretty awful and even with the Hashimoto transformer, it is pretty ordinary. Negative feedback makes all the difference in the Currawong, as it does in any other high-performance valve amplifier.

Next time you read how valve amplifiers can sound good without negative feedback, you will know that the writers are simply ignorant!

Various valves

A quick search of the internet will glean a lot of information, opinions and prices for various valve brands, ages and types. You will also see how many valve aficionados prefer "NOS" valves (New Old Stock) which have been manufactured up to 50 years ago but have never been used (and sometimes in the original box). If you go to **www.tubedepot.com** you will find more than 30 different types of 12AX7 priced from US$11.95 for a basic Electro-Harmonix right up to US$540.95 for a "Black Sable Mullard".

You may well wonder how much improvement you might get from the higher-priced valves. We would advise extreme caution. NOS valves can command high prices but it is very much a case of "buyer beware". Such valves may have been used (definitely not "new"!) and there are even forgeries of the most popular types.

If you have built the Currawong and then start swapping valves you may notice differences between similarly priced valves such as Electro-Harmo-

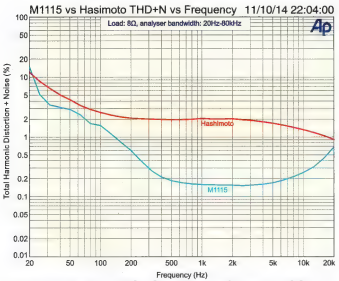


Fig.7: a comparison of the distortion performance of the M-1115 and Hashimoto transformers at 1W without negative feedback. Surprisingly, the M1115 has much lower distortion.

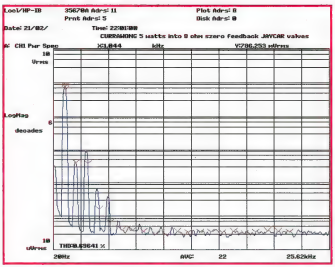


Fig.8: spectral response for the Currawong at 5W into an 8Ω load using the Jaycar-supplied Sovtek 12AX7 valves. The result is slightly different to that achieved when substituting valves from other manufacturers.

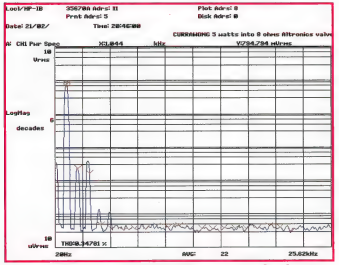


Fig.9: spectral response for the Currawong under the same conditions as Fig.8 but with the Electro-Harmonix 12AX7 valves supplied by Altronics instead.

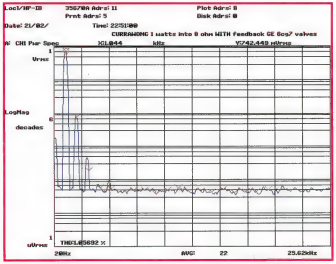


Fig.10: spectral response for the Currawong at 1W using 6CG7 valves but with feedback enabled. Note that these valves require a 6.3V filament supply.

nix (from Altronics) versus Sovtek (from Jaycar). But while these differences may be discernible and you might like one or the other depending on the type of music you prefer, objective tests will show that frequency response and total harmonic distortion are quite similar.

With that in mind, you might discount subjective differences. But it turns out that the differences are real and hence perceptible, which is backed up by the different spectra for these valves. You can see the results in Fig.8 & Fig.9. In both cases, the input signal is a 1kHz sinewave and spectra show the amplitudes of the various harmonics.

Apart from the multiple different brands of 12AX7 and 6L6 valves, you could also try 6CG7s in place of the 12AX7s but then you will need to run the filaments at 6.3VAC, not 12VAC. The 6CG7 is a very linear valve previously used in TVs for vertical oscillators to maintain a non-distorted picture. These valves are now available at Altronics.

The spectrum for the 6CG7 is shown in Fig.10. Note, though, that this was plotted at a 1W power level and with feedback enabled, in contrast to Figs.8 & 9. So use caution when comparing these results.

There is also the possibility for using KT66 valves in place of the 6L6s. These are significantly bigger and bulkier which does look more impressive. The performance is again very similar but they are more expensive. The Currawong PCB is designed to accommodate them.

Conclusion

We hope that readers now understand that the Altronics M1115 transformer really does deliver quite a respectable performance in the Currawong and especially so, given its low price.

Yes, we could have selected much more expensive transformers but the major increase in cost would simply not be justified in view of the small difference in performance. However, swapping valves to find which ones you prefer can be worthwhile and a lot of fun. SC

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Sticks to your desk and makes connecting or charging devices easier. No more need to duck beneath your desk to plug in your laptop! 2.1A dual USB output. 1.5m lead.

$70 SAVE $19
X 3216A 5m Reel
Top quality 5050 size LEDs

Create amazing lighting effects!
Magic RGB strip lighting with a huge array of colours and effects.
Sold in 5m rolls this strip light system includes control box and IR remote. IP65 rated for outdoor use. Great for adding atmosphere to your entertaining area. 12V DC input.

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$14.95 SAVE 25%
X 0250
Always charged up

Stylish Recessed LED Downlights
Includes transformer and mains connection lead!
10 Watt dimmable low profile design. Ideal for installations requiring Green Star rating. Superb clarity and light output. Only 42mm deep! 82-90mm cutout.

Suit new or retrofit installs!

X 2092
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Plugs into any mains outlet & lights up instantly when you walk past! Great for hallways and stairs. Can also be switched to permanent 'on'.

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Size: 125Wx155Hx88D mm.
Sold individually.
X 2902 Floodlight X 2904 Spotlight

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Premium 4WD CREE® LED Light Bars.
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Type	Part	Was..	NOW
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60W Floodlight 6xLED (281Wx64Hx92Dmm)	X 2913	$249	$195
100W Spotlight 10xLED (443Wx64Hx92Dmm)	X 2906	$399	$309
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Housed in a stylish diecast white powdercoated case this 1800 lumen flood bean CREE® LED is the perfect addition to your boat. UV stabilised flyleads with 304 rated stainless steel hardware. 9-32V DC operation. 2A current draw. Size: 106D x 91D mm. **Sold individually.**

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20A 12/24V	N 2012	$99
30A 12/24V	N 2014	$129

Battery Health Analyser

Detects and analyses voltage, cold cranking amperes, resistance and cell condition in 12V lead acid cells. Easy connection and on screen menu driven operation. Ideal for vehicle servicing or checking 12V SLA cells in battery backup systems.

$169 NEW!

Q 2120

Quick and accurate battery health check

Laptop & USB Car Charger

This compact supply simply plugs into a car accessory socket & provides regulated power to a laptop. Selectable voltages 15, 16, 18, 19, 20, 22 and 24VDC, up to 120W. Supplied with 8 adaptors to suit most laptops.

$44 SAVE 20%

M 8627A

$149 SAVE $30

M 8263 9-15V 30A

$129 SAVE $30

M 8261 9-15V 20A

Powertran® Analog Lab Power Supplies

These compact, fan cooled, switchmode power supplies deliver up to a huge 30A regulated output, adjustable between 9 and 15V. Plus fixed 13.8V setting. Ideal for comms equipment or servicing. Low noise design. 85% efficient. 155x70x205mm.

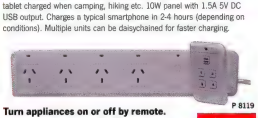
Lowest price ever!

$69 SAVE 24%

N 0706

15W Portable Solar Panel Charger

Provides up to 1A charge current for keeping car, caravan or 4WD batteries topped up. Ideal for portable situations where temporary charging might be needed, such as campsites. Includes croc clips and car accessory plug. Size: 977Lx342Wx22Dmm.



Folds up to about the size of an A4 book.

$88 SAVE $22

N 0710

Stay Charged Up On Your Travels!

This folding solar panel charger is an ideal way to keep your phone or tablet charged when camping, hiking etc. 10W panel with 1.5A 5V DC USB output. Charges a typical smartphone in 2-4 hours (depending on conditions). Multiple units can be daisychained for faster charging.

$37 SAVE 25%

P 8119

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NOW $4.95 WAS $7.95

S 4904 2xAAA

NOW $4.95 WAS $8.95

S 4906 2xAA

Charge 2 tablets at once!

$19.95 NEW!

M 8625

High Current USB Charger

Huge 4.8A current output. Ideal for charging two phones or tablets at once.

Test & Tools

Moisture Meter

Measures moisture levels in wood and building materials such as concrete, plaster, mortar etc. Ideal for monitoring damp or moisture ingress. Requires 9V battery.

$34.95 NEW!

Q 1255

Measure wind speed & temperature easily.

A compact thermometer & anemometer with max speed of 108km/h. Great for ventilation monitoring, experiments etc. Includes battery. Very easy to use!

$69.95 NEW!

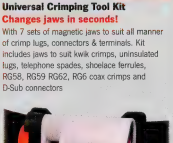
Q 1250

Pocket Rocket Blowtorch

One flick of the trigger and you have a whopping 1300°C flame ready for brazing or heatshrinking. Adjustable flame • One handed operation • Safety ignition lock • Refillable gas cartridge.

$15 SAVE 25%

T 2490



$99 SAVE $36

T 2177

Universal Crimping Tool Kit

Changes jaws in seconds!

With 7 sets of magnetic jaws to suit all manner of crimp lugs, connectors & terminals. Kit includes jaws to suit kwik crimps, uninsulated lugs, telephone spades, shoelace ferrules, RG58, RG59 RG62, RG6 coax crimps and D-Sub connectors

$15 SAVE 24%

X 0202

Waterproof Head Torch

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Noontec® Dual Tuner HD PVR Media Player

A great way to record your TV shows while watching another at the same time. Full timeshift capability with easy TV guide style schedule recording. In-built wifi makes it easy to connect to your local network files for instant streaming. Requires hard drive D 5513A 1TB $105.

Wireless sound anywhere you want it!

This wireless speaker uses the latest Bluetooth 4.0 standard with quick NFC device pairing with your smartphone or tablet. 40mm compact speaker and tuned enclosure • Hands-free phone functionality.

2.4GHz Wireless Headphones

Superb low noise digital transmission - a HUGE improvement in audio quality over traditional analogue RF models. USB dongle can be used with a PC or without a PC - ie: connect directly to an MP3 player. 30m range (line of sight). Requires 2xAAA batteries.

Stylish Hi-Fi Headphones

• Large ear pads for increased noise isolation. • Samarium cobalt magnets • 3.5mm plug & 6.5mm adaptor.

High Definition 9" Monitor With TV Tuner.

This 9" wide format LCD features in-built HD tuner to receive all the latest digital channels. AV input can be hooked up to your security system. USB port is provided for PVR recording. MP3 & video USB/SD playback. Easy to install.

Extend HDMI up to 100m using UTP cable.

Extends HDMI signal using economical Cat5e/6 cabling without sacrificing signal quality. IR control signals can also be relayed both ways. Supports Foxtel IQ. Includes receiver, transmitter, 2 IR targets, 2 IR emitters & power supplies.

Scale up 1080p to 4K resolution

Plus, extract digital audio from your HDMI signal along the way. A handy adaptor for 4K TV owners looking to upscale HD sources. S/PDIF audio out. Includes power supply.

Wake Up To Digital Radio!

An ideal bedside companion! Wake up to your favourite digital or FM station. Large display with scrolling info. Two alarms.

Lightweight Headphones

A great pair of commuter headphones with semi-open design offering excellent noise isolation and low noise leakage.

SOLO-6C Active Bookshelf Speakers

These Microlab® active bookshelf speakers represent amazing value for under $200 and are perfect for pairing with your television for home theatre use, or in the study for music and gaming. Requires no external amplifier! Sound output is impressive, with crystal clear dynamic highs, balanced mid range and deep bass. Dual stered RCA inputs for two audio sources. Includes IR remote control.

Weatherproof Speakers for the 4WD or Boat!

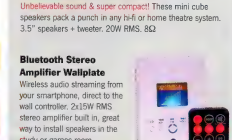
Maintenance free outdoor sound. These weatherproof 6x9" speakers are designed for long life in marine or tropical areas. Also great for caravans. 30W RMS. 4Ω.

Expand your sound system with ease!

Stylish 6.5" 8Ω ceiling speakers - great for the games room. Coaxial driver sounds great as surround sound effects or background music. Suits sheltered outdoor areas ie: under eaves, alfresco areas. 30W RMS.

Mini Surround Sound Speakers

Unbelievable sound & super compact!! These mini cube speakers pack a punch in any hi-fi or home theatre system. 3.5" speakers + tweeter. 20W RMS. 8Ω



Bluetooth Stereo Amplifier Wallplate

Wireless audio streaming from your smartphone, direct to the wall controller. 2x15W RMS stereo amplifier built in, great way to install speakers in the study or games room.

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The New Currawong 2x10W Valve Amplifier Kit

The Currawong amplifier is a tried and tested valve amplifier circuit which has been adapted to components which are readily available. Each channel uses two 12AX7 twin triodes for the preamp and phase splitter stages and two 6L6 beam power tetrodes in the class-AB ultra-linear output stage. It performs very well, with low distortion and noise.

Features:

- Two pairs of 6L6 beam power tetrodes
- Two pairs of 12AX7 twin triodes
- 2x10W RMS power output into 8 Ohm loads
- Remote volume control

Features both valve technology and solid state parts for a modern twist.

Supplied with: This kit includes all valves, PCB, componentry, acrylic board cover, transformers & panels. It **does not** include parts to build the enclosure. We suggest building your own to suit your own style.

High Power Ultrasonic Cleaner Kit

(SC August '10) Build this large, heavy duty ultrasonic cleaner and blast away grime from virtually anything, using just water & a little household detergent. Sensor can be dunked into a bucket of water for cleaning large items. Great for car parts, bric-a-brac and more! Requires 12V DC 2.5A plugpack, M 8937 $29.95 (fitted with 2.5mm tip).

433MHz Remote Control Trigger Kits

(SC January '09) These easy to build transmitter & receiver units can remote activate devices over a range of ~200m! Up to 5 receivers may be used, each driving a 12V relay. Ideal way to activate pool pumps, garden lighting, motorised blinds etc! Momentary or alternate. 9V battery powered.

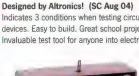
Smart Fan Controller Kit

(SC July '10). This compact module regulates the speed of up to eight 12V DC fans. Measures up to 4 temperature points & smoothly controls fan speed. May be monitored using PC software.

Cut Office Power Consumption

USB Mains Sensing Switch Kit.

(SC January '09) Monitors your PC's USB port and automatically turns all your gear on and off as required. No need to crawl under the desk to disconnect devices!

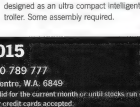


Logic Probe Kit

Designed by Altronics! (SC Aug 04) Indicates 3 conditions when testing circuits & devices. Easy to build. Great school project! Invaluable test tool for anyone into electronics.

PC Birdies Kit

(SC Aug '13) An educational and fun kit to build for electronics beginners. Re-creates the sound of a tweeting Canary at random intervals. Includes Jiffy box case.



Mini-Maximite Embedded Module

(SC November '11) The 'little brother' of the Maximite kit. Utilising identical software it is designed as an ultra compact intelligent controller. Some assembly required.

2x20W 12V Amplifier Kit

(SC May '10) This compact stereo amp module puts out 2x20W RMS into 4Ω and is 12V powered (SLA battery or plugpack). Distortion typically <0.03%. Bass & treble controls. Great for mobile use in a caravan.

'Classic-D' Amp Module Kit

(SC November '12) A rugged and reliable Class-D audio amplifier producing up to 250W into 4Ω. This high efficiency, high power design is ideal for building into any audio amplifier design. Class-D amps are commonplace amongst consumer equipment. Low distortion <0.01%. Based on the IRS2092 audio amplifier chip. **K 5182 optional speaker protector $19.95.**

Versatimer Switch Kit

(SC June '11) Drives a 12V latching relay for switching applications requiring a low current drain. Also provides a battery discharge feature for use with SLA batteries. In-built timer (1s-5hrs) can be triggered from external contacts.

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CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Remote sensing & controlling a Micromite with HC05 Bluetooth modules

There are already functions (SSETPIN, SPIN and SPIN()) which allow two Micromites to communicate with each other over a hard-wired I²C bus. One Micromite will act as the master while the other acts as the slave (see appendix B of the Micromite manual).

Being hard-wired, the main use for this type of connection would be to use the slave in close proximity to the master as an extension of the master by doubling the I/O lines available for use. But what if you wanted to control the slave in a remote position where long wire lengths would be inconvenient or unreliable? Such situations requiring remote sensing and control are quite common and this circuit shows how it can be accomplished using a Bluetooth radio connection between the two Micromites.

The circuit uses HC05 modules, which cost about $8 or less on the web. These modules operate at 3.3V and require a serial interface using TTL, also at 3.3V. To be effective, the module needs a LED and various other soldered connections. Soldering to the module is rather tricky so the best way to purchase the HC05 is the breakout board form which mounts the module on a small circuit board and brings out the main connections to six pins labelled STATE, TxD, RxD, GND, V_{CC} and EN (or KEY).

It also incorporates the required LED and has a voltage regulator allowing it to be operated from 5-6V supplies although it will still work from a 3.3V supply. However, the TxD and RxD pins must be operated using TTL at 3.3V.

The boards operate in two modes: programming and communications. The programming mode allows parameters such as baud rate, password, master, slave etc to be set. In this mode, the boards are ready to pair with other available boards. Communication is only possible when one board is set as the master and the other is set as a slave and the passwords on each are the same.

The first thing to do is to set some of the important parameters of your two Bluetooth boards. To do this you must connect the Bluetooth board to your computer via a TTL serial connection as shown in Fig.1. This connection is the same as the serial console you are using to connect your Micromite to your computer for programming.

To do this, you are probably using a terminal emulation program such as Tera Term with either a USB to TTL serial converter or perhaps the RS232-to-TTL converter using COM1 as featured in a previous Circuit Notebook article. As well, Tera Term is most likely set at the Micromite default value of 38,400 baud, which is ideal since that is also the default rate for the HC05.

The following settings are needed for Tera Term:
(1) Set the baud rate to 38,400 baud; 8-bit; no parity; 1 stop bit; no flow control (if not already set at that).
(2) Under Setup/Terminal, change Transmit from CR to CR+ LF.
(3) Tick the box "local echo".

The board must now be put into programming mode with a serial baud rate of 38,400. Unfortunately, there are at least two different versions of the board. One has KEY as the name of one of the six pins, the other (the one I used) names this pin as EN and also has a micro momentary switch located just above the EN pin. I have labelled this switch PGM in Fig.1.

On the KEY version, first connect KEY to 3.3V and then apply 3.3V to V_{CC}. On the EN version, with EN disconnected, press and hold the PGM switch and then apply 3.3V to V_{CC}. Now release the PGM switch. The LED on the board should start flashing slowly at about one flash every 2s. If it is flashing rapidly (~3Hz?) you are probably in communications mode, so try again.

Once in programming mode, type AT <enter> in Tera Term and you should get an "OK" response from the device. All commands should be in upper-case and terminated with the enter key.

If contact has been established, type the following programming commands to set this board as the master:

AT+UART=38400,0,0 – This sets the communications baud rate to be the same as the serial connection baud rate.

AT+ROLE=1 – sets this board as the master.

AT+CMODE=1 – sets the device to pair with any available slave Bluetooth device.

AT+PSWD? – checks the password of the master. The 4-digit password must be the same on the slave as it is on the master. The default is 1234.

Now set the second device to be the slave. Repeat the sequence above but make one change: **AT+ROLE=1** becomes **AT+ROLE=0**. If the password on the slave does not match that on the master, it can be changed using **AT+PSWD=XXXX** where XXXX is the numerical sequence you found in the master.

You can check the state of any parameter by typing the stem of the command followed by a "?". For example, to check the baud rate, type **AT+UART?** It would be a good idea to search the web and download the complete list of programming commands.

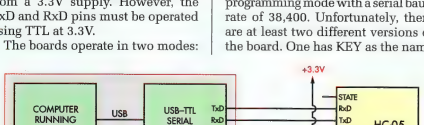


Fig.1: the Bluetooth HC-05 modules are set up by connecting them to your PC via a USB-TTL serial converter.

If you now power up both master and slave with KEY or EN disconnected, they will enter communications mode. The LED on both devices will flash rapidly (~3Hz on my devices) as they attempt to pair. Pairing occurs quite quickly and once achieved, the flash rate of the LED changes pattern to two quick flashes every 2s. The STATE pin also goes high and remains high while ever pairing is maintained.

With the Bluetooth modules paired, they can be put to use. Fig.2 shows a master Micromite and a remote slave Micromite, both connected to their own HC05 boards. In each case, TxD on the HC05 is connected to the COM1 Rx input of the Micromite (pin 22) and RxD connects to the COM1 Tx output (pin 21).

For consistency, I used the master HC05 with the master Micromite. The STATE pin of the HC05 master connects to LED1 via a 270Ω resistor and to Micromite pin 24. This LED will be steadily lit once pairing is achieved.

The serial console connected to pins 11 & 12 is the device you are using to connect the Micromite to your computer for programming and is the same as used in Fig.1 to program the HC05. You should program the master Micromite with "Master.bas" and the slave should similarly be programmed with "Slave.bas". Both programs are available on the Silicon Chip website.

Master.bas contains subroutines and a function to enable the master Micromite to control outputs and remotely sense inputs on the slave. RSETPIN is a subroutine used to set the slave's pin as an input or output. For example, RSETPIN 2,1 will set the slave's pin 2 as an analog input.

Subroutine OUTPIN is used for assigning a value (0 or 1) to a pin on the slave previously set as a digital output. So for example, OUTPIN 25,1 will cause pin 25 on the slave to go high. Naturally, you would have to had previously issued the instruction RSETPIN 25,8 to make slave pin 25 a digital output pin.

Finally, READPIN is a function which will read the value of an input pin on the slave. If pin 2 has previously been defined as a digital input, the function READPIN(2) will be either 0 or 1 depending on the state of pin 2. If pin 2 has been defined as an analog

. . . continued on page 84

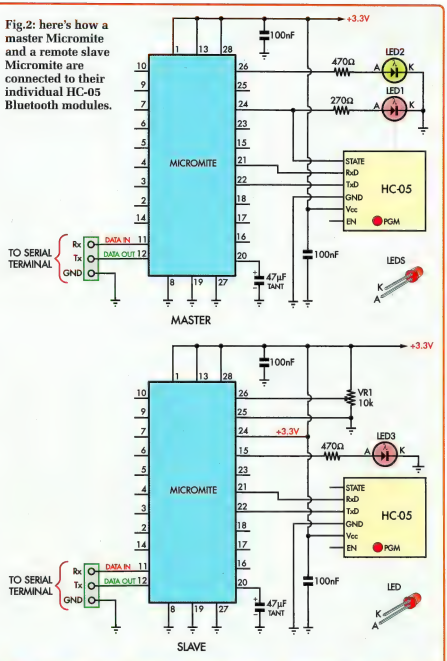
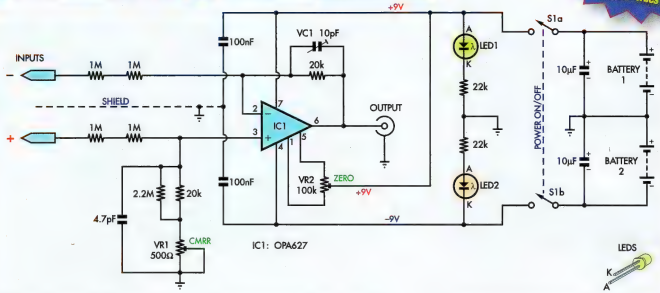


Fig.2: here's how a master Micromite and a remote slave Micromite are connected to their individual HC-05 Bluetooth modules.

Peter Kay is this month's winner of a $150 gift voucher from Hare & Forbes



Poor man's mains voltage scope monitor

This circuit was prompted by the "High Voltage Probe For Oscilloscopes" in the January 2015 issue, with the thought there must be a cheaper way to do a similar job using a fully differential amplifier with only a 100:1 attenuator. It uses an OPA627 op amp which is fast (16MHz GBP), low noise (10nV/√Hz) and has low offset (100µV). They cost about $30 each.

If cost is a problem, then any fast high slew rate op amp (>10V/µs) can be used with somewhat compromised performance, eg, OPA131.

It is fully differential and has at least 60dB of common mode rejection @ 50Hz, less than 1mV of output noise and has a rise-time of about 100ns (5MHz bandwidth), with zero overshoot.

The resulting performance specification is as follows:

Attenuation: 100:1 (±2%)
Input voltage: ±700V
Rise time: 100ns
Noise: 1mV peak-peak (wide band) or 0.2mVp-p (<100kHz)
CMRR: >60dB up to 1kHz; >40dB @ 10kHz; -10db @ 500kHz
Input impedance: 2MΩ singled-ended; 4MΩ differential.

The four 1MΩ input resistors must be rated at more than 500V. Two 1MΩ resistors are used in each input leg to satisfy safety requirements (any single failure is still safe).

The battery supply can be replaced with external ±9V to ±15V supplies. If ±15V supplies are used, then signals up to ±1300V can be monitored.

Adjust trimpot VR1 to maximise the Common Mode Rejection Ratio at 50Hz. This is done by connecting both inputs to the 230VAC and then adjusting VR1 to obtain the minimum displayed signal on the oscilloscope.

To adjust trimmer VC1, connect the probe circuit to the 1kHz square wave calibration signal on your oscilloscope and set it for the fastest rise time without overshoot; typically 100ns. While not strictly necessary when using an OPA627, adjust trimpot VR1 for minimum DC offset (with no input signal) at pin 6 of IC1.

Peter Kay (BE Elec), Dromana, Vic.

Editor's note: unlike the High Voltage Probe For Oscilloscopes in the January 2015 issue, ***this circuit does not provide full isolation between high voltage signal sources (eg, a 230VAC-power motor speed controller) and the measuring oscilloscope.***

Optimising the common mode rejection ratio with trimpot VR2 is critical to obtaining a true rendition of the wanted differential waveform. Similarly, adjustment of trimmer capacitor VC1 is necessary to minimise overshoot on fast rising waveforms and naturally, PCB layout will be most important.

Micromite Bluetooth modules ***. . . continued from page 83***

input, READPIN(2) will return the value of the voltage at pin 2.

Looking now at the slave connections, the slave has pin 26 connected to the wiper of VR1 and so can have any voltage between 0V and 3.3V applied to it. Pin 25 is connected to logic low and pin 24 to logic high These three pins are used by the master program to demonstrate remote sensing of the slave's inputs. Pin 15 is connected to drive LED3 and is used to demonstrate how the master can control a digital output.

The sample main program on the master Micromite uses RSETPIN to assign pins on the slave in the following way: Pin 15 digital output; pins 25 and 25 digital input; and pin 26 analog input. The program then uses READPIN to read the three input pins and prints their values. OUTPIN is used to flash LED3 connected to the slave's pin 15 at a 0.5Hz rate.

The slave program simply drops into a continuous loop which listens for a command to be issued by the master. When it receives this command, it will execute the command and send an acknowledgement to the master to indicate it is still awake.

If the master doesn't receive an acknowledgement, a watchdog timer will cause it to restart with an error indication. LED2 connected to pin 26 of the master is the transmission error indicator. If for any reason the slave fails to acknowledge a command from the master, LED2 will be lit on the ensuing restart. This is a visible

Software Listing

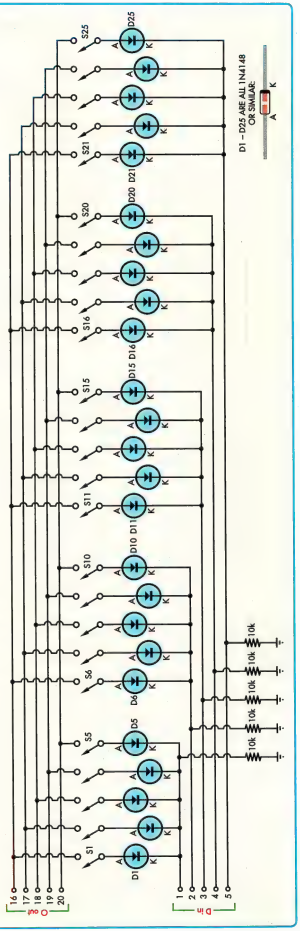
```
3 GoSub 7000
5 Cls
10 Do
15 GoSub 100
50 GoSub 6000
80 If Inkey$ = "n" Then End
90 Loop
100 Rem read pins for point and signal switches eg signal clear-sw1=1
      danger-sw1=0
110 Pin(16) = 1 : Pin(17) = 0
115 s1 = Pin(1) : s6 = Pin(2) : s11 = Pin(3) : s16 = Pin(4) : s21 = Pin(5)
120 Pin(17) = 1 : Pin(18) = 0
125 s2 = Pin(1) : s7 = Pin(2) : s12 = Pin(3) : s17 = Pin(4) : s22 = Pin(5)
130 Pin(18) = 1 : Pin(19) = 0
135 s3 = Pin(1) : s8 = Pin(2) : s13 = Pin(3) : s18 = Pin(4) : s23 = Pin(5)
140 Pin(19) = 1 : Pin(20) = 0
145 s4 = Pin(1) : s9 = Pin(2) : s14 = Pin(3) : s19 = Pin(4) : s24 = Pin(5)
150 Pin(20) = 1 : Pin(16) = 0
155 s5 = Pin(1) : s10 = Pin(2) : s15 = Pin(3) : s20 = Pin(4) : s25 = Pin(5)
6000 Rem print values for switches
6110 Locate 0,0
6220 Print "s1 to s5 ";s1,s2,s3,s4,s5
6221 Print "s6 to s10 ";s6,s7,s8,s9,s10
6222 Print "s11 to s15 ";s11,s12,s13,s14,s15
6223 Print "s16 to s20 ";s16,s17,s18,s19,s20
6224 Print "s21 to s25 ";s21,s22,s23,s24,s25
6225 Return
7000 Rem sets up pins
7150 For z = 16 To 20 : SetPin z ,oout : Next
7160 For z = 1 To 5 : SetPin z ,din : Next
7200 Return
```

5 x 5 switch matrix for the Micromite

This circuit was developed to control part of a model railway with a Micromite computer. It needed 18 inputs for blocks, 16 inputs from switches and at least 54 outputs. This was to provide 18 block occupancy indicators, nine 3-aspect signals and nine for track control. The colour Micromite has enough pins for the inputs (just); all outputs are via I^2C.

To provide the switches, a 5 x 5 matrix was used which gives 25 switches (nine for future use) and it uses just 10 pins of the Micromite; five inputs and five outputs. By pulling the five inputs high in succession, the Micromite can then monitor the five inputs and thereby detect which switches are closed. The diodes prevent false sensing when multiple switches are closed simultaneously. External pull-down resistors are used for EMI tolerance.

John Sheldrake,
Wynnum West, Qld. ($45)



indication that an error has occurred and its cause needs to be investigated.

When power is first applied to the master, the master HC05 board will need a little time to pair with the HC05 board on the slave (assuming you have already turned the slave on). The STATE pin on the master's HC05 connects to pin 24 of the master Micromite and will go high when pairing has been achieved. This in turn will light LED1 as a visible pairing indicator. On start-up, the master Micromite will wait for this high on pin 24 to occur before continuing on to issue commands to the slave.

Jack Holliday,
Nathan, Qld. ($70)

Amateur unmanned vehicles pushing the limits on altitude, long range and high speed

REACH FOR THE SKY

... and way, way beyond

Part 2: By Dr DAVID MADDISON

In last month's issue we told how amateur balloonists, kite fliers and model aircraft enthusiasts are achieving amazing results and setting new records. This month we go even further with model rocketry.

Apart from balloons, rockets are the other way to get into space. Some amateur rocketry attempts are very impressive.

For an overview of amateur rocketry in the US see "Amateur Rocketeers Reach For The Stars – KQED QUEST" http://youtu.be/nurJm0XkU7I

In one example a US amateur, Derek Deveille and his team flew their rocket "Qu8k" (pronounced "quake") to 121,000ft at a maximum speed of 3,516km/h in September 2011. The rocket was 8m long and 20cm in diameter and weighed 145kg at lift off (see left and right).

It took 92 seconds to get to maximum altitude and the total flight time was 8.5 minutes. The rocket, which was launched in the Black Rock Desert in Nevada, was recovered substantially undamaged (except some scaring from aerodynamic heating) about 5km from the launch site. For video of the launch see YouTube video "Qu8k - BALLS 20 - Carmack Prize Attempt - High Altitude Rocket On-board Video" http://youtu.be/rvDqoxMUroA and Derek's web page http://ddeville.com/derek/Qu8k.html

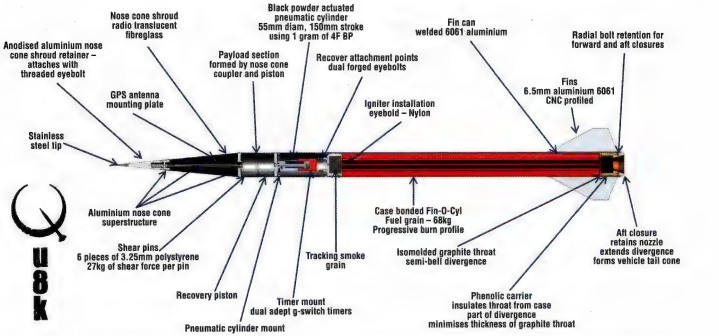
Amateurs putting a man in space?

While this article has discussed unmanned aircraft and rockets an amateur-built manned spacecraft is certainly worthy of a mention here. Perhaps the ultimate amateur achievement would be to put a human being into space. This is the objective of the non-profit organisation Copenhagen Suborbitals http://copsub.com/ Their objective is to put a person into space to demonstrate that you don't have to be a large government or other big budget organisation to do this.

Copenhagen Suborbitals have a philosophy of developing simple solutions to complex problems. The rocket engines use ethanol and liquid oxygen and the spacecraft is designed to carry one person into space in a suborbital flight.

They have already achieved many firsts such as the most powerful amateur rocket ever flown, first amateur rocket to carry a human-size payload, first amateur rocket to have issued a "main engine cut-off" command and first sea launch of a rocket by a small organisation.

One of many challenges for this project was the development of a flight computer system. Each major component



Working components of US amateur Qu8k ("Quake") rocket which reached an altitude of 121,000 feet and a maximum speed of 3,516km/h – enough to cause aerodynamic heating damage to some components.

such as motor, boosters, guidance system and capsule will have its own computer which will communicate with others via a serial bus.

Such computers have to be ruggedised for the vibration, heat, cold and vacuum of rocket flight and are not readily commercially available so Copenhagen Suborbitals decided to develop their own. They chose the Arduino platform as a basis for their flight computers but designed their own ruggedised boards which also included modules on board which would normally be separate in a traditional Arduino system. They designated their system CS-duino.

Tolerance for the cosmic rays of space and also vacuum were two particular challenges to be dealt with. Electrolytic capacitors cannot be used in a vacuum or extreme cold so alternatives had to be found. Cosmic rays can introduce unwanted logic states in digital electronics and components cannot be readily shielded.

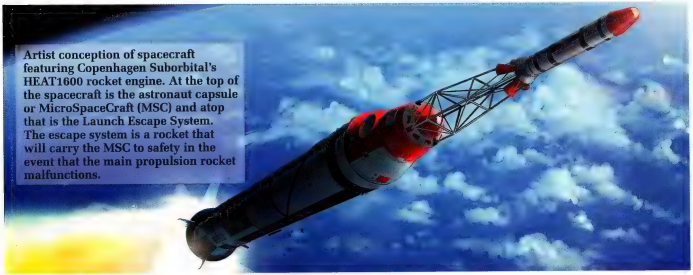
Copenhagen Suborbital determined that a cosmic ray strike can be detected when the current consumption of the computer suddenly spikes. If this happens the computer is quickly rebooted and data variables are restored from non-volatile memory, allowing the computer to continue operation with little interruption.

The designers have also chosen older, more rugged components such as bipolar transistors instead of Mosfets. These are more resistant to cosmic rays.

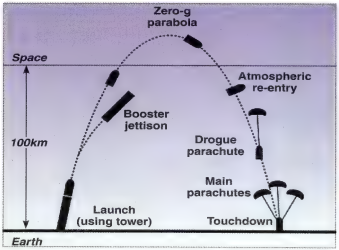
Unfortunately, the regulatory regime for rocketry here in Australia seems highly restrictive compared to the US for much more than "toy" rockets with many hoops to jump through and very little to encourage participation in serious amateur rocketry activities.

In the ACT, for example, even toy model rocket motors are illegal, let alone serious rocket motors of the type described here (theoretically some may be permitted but none have been "authorised")!

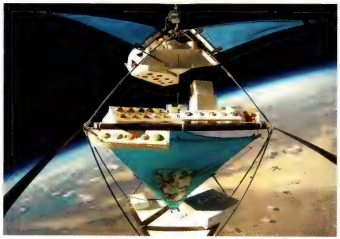
These laws really need to be reviewed to encourage greater



Artist conception of spacecraft featuring Copenhagen Suborbital's HEAT1600 rocket engine. At the top of the spacecraft is the astronaut capsule or MicroSpaceCraft (MSC) and atop that is the Launch Escape System. The escape system is a rocket that will carry the MSC to safety in the event that the main propulsion rocket malfunctions.



Flight path of planned sub-orbital flight.



A carrier frame containing PongSats beneath a balloon. As can be seen, the balloon is already at high altitude.

participation in this hobby. It is hard to think of a more ideal country for this hobby with our wide open spaces.

Satellites

Amateurs radio operators have been launching their own satellites into space since 1961 when OSCAR 1 was launched. It piggy-backed into space in a NASA rocket and it was a substitute for a balance weight used in the rocket.

It was thus built in a very specific shape to replace what would otherwise been a dead weight . However, it is difficult for private individuals or small groups to launch their satellites this way.

PongSat

PongSats are not real orbital satellites but do achieve very high altitudes on weather balloons and the air pressure at maximum altitude is only about 1% of what it is at ground level. PongSats can do useful science for young students (or even adults!).

PongSats use a ping pong ball as a container for their experimental payloads. Whatever can fit in a ping pong ball can be flown subject to certain restrictions such as no insects or other animals, volatile chemicals and weight below 85g.

PongSats are flown free for students by JP Aerospace, "America's OTHER Space Program", a volunteer-based DIY space program. Many PongSats have been flown for Australian students.

PongSat experiments that have been flown by students include everything from simple ones such as seeing what happens to a marshmellow at altitude or to see if plant seeds remain viable after exposure to cosmic rays at high altitude to more complicated experiments such as putting computers with atmospheric sensors and data loggers inside the balls. The ping pong balls are cut in half and then taped together with their payload inside. Each PongSat balloon mission can hold 500 PongSats.

See YouTube video "PongSat Mission April 2013" http://youtu.be/GZobW3nuYNs which features the launch of six balloons carrying 2,400 PongSats to altitudes of between 92,000 and 103,000 feet.

To date JP Aerospace has launched over 17,000 PongSats involving 45,000 students and the program is open to everybody and there is no charge to students or schools.

Some student PongSats before launch. The contents must fit inside a ping-pong ball and weigh less than 85g.

MiniCube

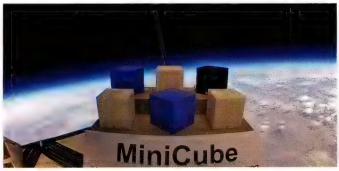
JP Aerospace offers another method called the MiniCube for amateurs to fly their payloads to near-space.

This is a box 5cm on each side into which you incorporate your payload package. For a fee of US$320 (currently discounted to US$270) you will be supplied with a MiniCube box into which you install your instrument package and then return it to JP Aerospace for it to be flown. For details see http://www.jpaerospace.com/

JP Aerospace also has an extremely ambitious "airship to orbit" program which involves three different vehicles to get to orbit.

You'd be amazed at just how much can be crammed inside a ping-pong ball . . .

A double PongSat with processor and sensors on one side and a solar panel that tracked the sun in the other.



MiniCubes at altitude. An inexpensive way to get a small payload to near-space.

The first stage involves an airship of seven times greater volume than the Hindenburg. It will have a crew of three and will ascend to 140,000 feet using a combination of buoyancy and aerodynamic lift, with propellers designed to operate in a near vacuum.

This first stage airship will dock with a "Dark Sky Station" permanently parked (floating) at 140,000 feet. It will be a gigantic structure and will act as a way station to space. This structure will also be the place where the third stage vehicle is assembled and its departure point.

The third stage vehicle will be an airship of truly staggering proportions, the test vehicle alone will be some 2,000m long to give it the buoyancy to float to 200,000 feet.

From 200,000 feet it will use a combination of chemical and electric propulsion to reach orbital velocity over a period of 9 hours.

For information from JP Aerospace see www.jpaerospace.com/atohandout.pdf For information from Wikipedia see http://en.wikipedia.org/wiki/Orbital_airship. See also "Airship to Orbit Animation" at http://youtu.be/iA45XcmUB8Q

PocketQube

Unlike PongSats, PocketQubes are genuine orbital satellites. PocketQube is a miniature satellite format with a basic unit size of 5 x 5 x 5cm with a mass no greater than 180g.

These satellites should not be confused with another miniature satellite format, the CubeSat with a unit dimension of 10cm x 10cm x 10cm. As with CubeSats, PocketQubes come in a form factor of one, two or three units in length (1P, 2P or 3P) or some intermediate amount such as 1.5P.

The first four PocketQube satellites were launched on 21st November 2014.

While PocketQubes are not "cheap" they are the cheapest way to get your own satellite into space. CubeSats might cost US$125,000 per satellite including orbital insertion but a PocketQube mission might cost US$20,000 or less, including the cost of the satellite and insertion into orbit if using commercial PocketQube components.

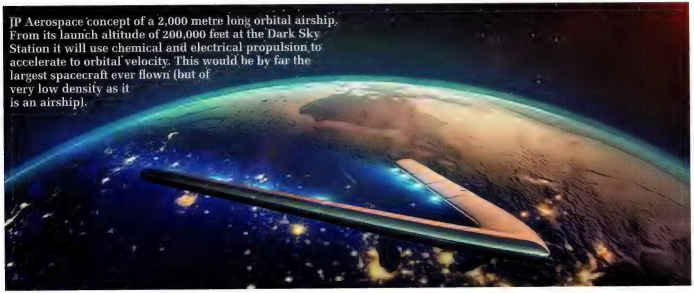
That pricing might be too much for most individuals but it is well within the capacityof groups of individuals or associations. Funding could also be by crowd-funding or sponsorship.

$50Sat

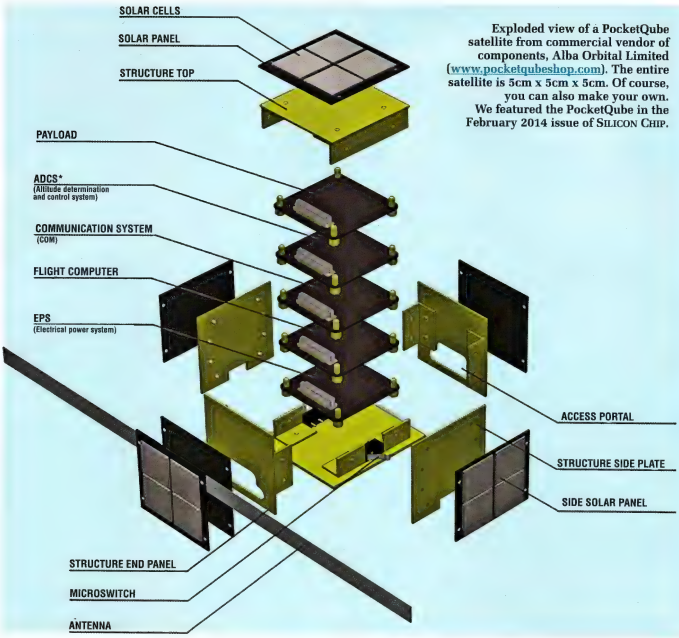
PocketQubes can also be built very inexpensively if not using commercial PocketQube components. One of the first four PocketQubes to be launched as mentioned above was perhaps the world's cheapest and smallest operational satellite. It is called the $50SAT – Eagle 2 and despite the name cost about US$250 in parts (of course, this figure does not include the launch cost).

Featured in an article in SILICON CHIP in February 2014, it was a collaborative project between Professor Bob Twiggs, KE6QMD of Morehead State University in Kentucky, USA and three other radio amateurs, Howie DeFelice, AB2S, Michael Kirkhart, KD8QBA, and Stuart Robinson, GW7HPW.

Its purpose was to develop a cheap satellite platform for engineering and science students and have the students



JP Aerospace concept of a 2,000 metre long orbital airship. From its launch altitude of 200,000 feet at the Dark Sky Station it will use chemical and electrical propulsion to accelerate to orbital velocity. This would be by far the largest spacecraft ever flown (but of very low density as it is an airship).



Exploded view of a PocketQube satellite from commercial vendor of components, Alba Orbital Limited (www.pocketqubeshop.com). The entire satellite is 5cm x 5cm x 5cm. Of course, you can also make your own. We featured the PocketQube in the February 2014 issue of SILICON CHIP.

develop skills building it.

The satellite has two 40mm x 40mm circuit boards, including a PICAXE 40X2 processor, a Hope RFM22B single chip radio and other support electronics. Interestingly, from pictures it can be seen to be using a metal measuring tape for its antennae, a cheap, reliable, innovative and cost effective solution for automatic antennae deployment used on many lower cost amateur radio satellites including Australia's OSCAR-5 which was built in 1966 but not launched until 1970 (the first amateur satellite built outside of the United States).

The $50Sat is built with a PocketQube 1.5P length form factor so its size is 5cm x 5cm x 7.5cm.

Professor Twiggs said "We really did not set out to build the cheapest satellite at all, but the idea was to make the simplest possible satellite that still fulfilled all the basic requirements for reliability and two way communications."

"The motto we used was 'you can't add simple' and rather than try to add some grand technical experiments or payload, we deliberately left them out. We wanted to minimise the risk of anything going wrong in order to prove the PocketQube concept and the more complex the satellite was made the more likely this was to happen."

If you want to see the current location of this satellite go to www.satview.org/?sat_id=39436U It transmits a 100mW signal at 437.505Mhz with a variation of 10kHz up or down depending on the Doppler shift. Its OSCAR amateur radio satellite designation is MO-76 (Morehead OSCAR 76). You can also listen to its Morse call sign with a standard handheld UHF receiver (preferably with a good antenna) when the satellite is 800km away or closer.

Apart from a slow Morse Code call sign the satellite also transmits telemetry about its operaton as fast 120WPM Morse and as FSK RTTY.

Full information on that satellite including design data and software listings (in case you want some ideas for building your own) is available at www.dropbox.com/sh/l3919wtfiywk2gf/-HxyXNsIr8

The ultra-inexpensive $50SAT – Eagle 2. The world's cheapest functional satellite? Note the measuring tape antenna!

Also flown as one of the first of four PocketQubes on 21st November 2013 was the WREN PocketQube which has a camera and micro plasma thrusters to manoeuvre. As described by themselves it was built by "four guys in a garage".

It has a software package that financial supporters were supposed to be able to use, to control the satellite to take pictures. A pre-launch video of this satellite is on YouTube "Fly a Satellite in Space...Without Leaving Your Couch" http://youtu.be/TVGJqNofibo

Aerospace has always been a high risk business, even for amateurs. Unfortunately the WREN satellite never went operational and the organisational web page www.stadoko.de/?lang=en is inactive.

Of the two other PockeQubes launched, QubeScout did not go operational and TlogoQube went operational but stopped responding in January last year.

As of the new year (2015) $50SAT was still operational.

Conclusion

This series has presented a brief survey of amateur-built high altitude, long range and high speed flight. This included a variety of air and space vehicles such as kites, balloons, fixed wing and rotary winged aircraft and rockets.

Nearly all of the achievements would have been impossible or at least much more difficult without advances in electronics and miniaturisation, along with mass production to lower the costs to an affordable level.

Some of these technologies such as autonomous flights by multirotor aircraft have the potential to change our way of life.

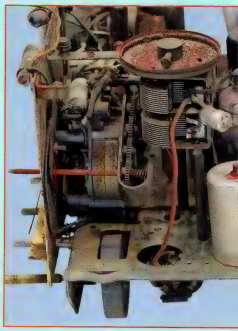
Google, Dominos Pizza and others have long term plans to deliver packages to the home via these aircraft but before that can happen, there are many regulatory and safety issues to consider (you don't want the delivery vehicle or its payload falling on people or property!).

Many of these achievements have been undertaken by amateurs with a can-do attitude, doing whatever it takes and it is hoped that in the future regulations are either maintained (at worst) or liberalised to allow such great amateur achievements to continue. **SC**

Vintage Radio

By Associate Professor Graham Parslow

Tela-Verta 1948 Musiclock Model 204C Mantel Radio



Designated the model 204C, this classic art-deco mantel radio incorporated a 5-valve superhet chassis and a Smith's Selectric clock movement with alarm & sleep functions.

D. W. Radio Co (Tela-Verta) manufactured radios in Sydney from 1934-1948. It was owned by Herbert and Frank Warby who started their business as a partnership at 210 Willoughby Road, Naremburn.

The business subsequently moved in 1939 to 32 Alexander Avenue, Willoughby. It then relocated again in 1946 to 466 Victoria Avenue, Chatswood and a sketch of that building appears under the Tela-Verta banner reproduced with this article.

During their 14-year history, Tela-Verta produced over 30 models ranging up to 8-valve console radios of a high standard. The advertisement for the TV-24A mantel radio reproduced later in this article shows that it used the same case as the model 204C. The cost of setting up a mould for a custom-made Bakelite case was prohibitive for small companies like D. W. Radio so they used a generic case and fitted a range of variant models inside.

This particular case was also shared by other manufacturers using the Mendelssohn, Aristone, Midlands and Air King brand names. The Tela-Verta colours of the case were eau de nil (green), ivory and figured walnut (as in the example featured here). Other manufacturers offered additional colours including blue and pink.

The Tela-Verta 204C

The 204C model incorporated a Smith's Selectric clock movement with alarm, wake-to-music and sleep functions. The photo immediately above shows the synchronous motor and gears used in this clock. It also clearly illustrates the poor state this example was in before work began.

A front-panel control was used to switch the alarm function on and off but this was deleted from the restored radio. A small knob to the right of the dial sets the alarm time, while a knob at the rear sets the time.

Unfortunately, the clock's hands were missing and the rest of the mechanism was deemed to be beyond repair. As a result, all the electric clock parts were removed during the restoration and a modern quartz alarm clock movement substituted.

Circuit details

Fig.1 shows the circuit details of the model 204C. It's a conventional

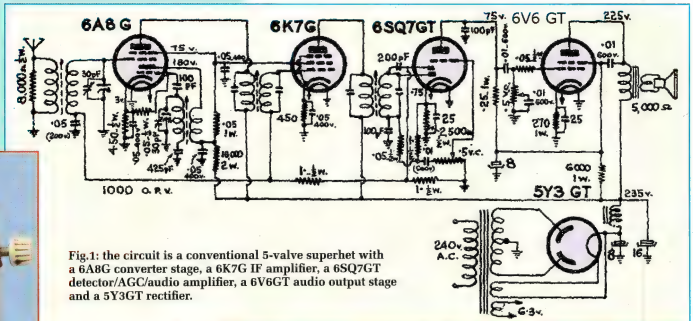


Fig.1: the circuit is a conventional 5-valve superhet with a 6A8G converter stage, a 6K7G IF amplifier, a 6SQ7GT detector/AGC/audio amplifier, a 6V6GT audio output stage and a 5Y3GT rectifier.

Left: the clock mechanism (to the left of the tuning gang) was in a poor state and was replaced by a modern quartz clock movement.

Right: these two photos show the condition of the old Tela-Verta radio before restoration.

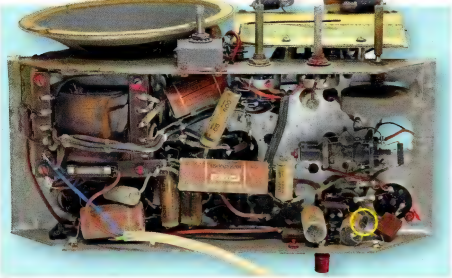
5-valve superhet so there are no radical surprises. It consists of a 6A8G converter stage, a 6K7G IF amplifier, a 6SQ7GT detector/AGC/audio amplifier, a 6V6GT audio output stage and a 5Y3GT rectifier.

The most striking component variation is the use of a metal-cased 6K7G valve as the IF amplifier. The metal acts as a shield and is more rugged than glass. The base of the 6SQ7 detector/audio amplifier also has a manufacturer-added metal shield.

The volume control works by feeding a sample of the detected audio to the 6SQ7's grid. This worked well across its range in the restored radio, as did the "top-cut" tone control (wired across the input to the 6V6). I was happiest when listening without any "top-cut" to the audio, however.

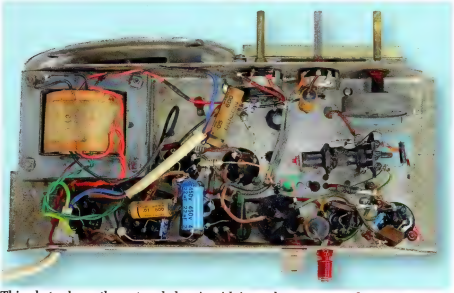
The set's history

The radio featured here was owned by a friend and was given to him by his family when he was a young boy. The radio was a few years old when he got it but it was quite a privilege in those days to have a personal radio.



The reason the radio had originally stopped working was simple – the 450Ω resistor (circled) in the 6A8's cathode circuit had gone open circuit. This left the cathode floating so that the valve could no longer function as a mixer-oscillator.

The clock face is positioned directly behind the dial which carries the hours and minutes markings.



This photo shows the restored chassis with its replacement transformer & various other parts. The mains cord was later securely anchored using a clamp.

It worked well for many years until one day it suddenly stopped. My friend then stored it in an open-top cardboard box and that is how I eventually received the radio, as a gift to add to my collection.

By that time, it was in poor condition in every respect, particularly the exposed top of the cabinet where photochemical decomposition had powdered the surface of the Bakelite. It had no knobs fitted but an additional grimy plastic bag came with the unit and this contained the three knobs and two screws.

The screws secured the chassis to the moulded case but why had they and the knobs been removed? By deduction, it was because the radio had stopped working and someone had slipped the chassis out, looked at it and given up on fixing it.

In the condition it was received, the cabinet looked like it would never see its glory days again. However, once the restoration work had been completed, I was delighted at just how well the figured walnut colour had survived under the layer of decomposed Bakelite.

The first step with the cabinet was to scrub it with degreaser to wash off a large amount of the brown residue. The water eventually stopped turning brown and the case was then wiped and dried. The result was a case that looked just as dull as when I started.

A miracle of transformation was brought about by application of several coats of ArmorAll silicone surface polish. The surface was porous and soaked up the polish until eventually a uniform gloss prevailed. In bright light, the walnut pattern was now beautifully evident as can be seen in the photo at the beginning of this article.

The speaker grille cloth was intact and was ultrasonically cleaned in soapy water. Lots of dirt literally fell out of the fabric and the cloth came up looking like new. The glass dial face was then carefully cleaned and glued back into position.

Chassis restoration

By this stage, the cabinet was looking pristine and that encouraged me to get on with the electrical restoration. The chassis was corroded and covered with dust, so a fair amount of work would be required to restore it.

The set came with a mains cord fitted but its terminations at both ends left a lot to be desired. That, plus the general condition of the chassis, meant that it wouldn't be a matter of simply plugging it in and seeing what happened (an unwise move in any event).

Instead, I decided to try what a rather "rustic" member of the Historical Radio Society told me worked for him. That was to wash a chassis down aggressively then leave it for a month or so to let everything dry. As a result, I removed the valves and washed the chassis down. I couldn't see any practical way to protect the

power transformer with a plastic bag so I simply washed everything in-situ.

Fortunately, the weather was warm and dry and so I waited for just five days for it to dry out. Everything certainly looked dry by then, so I rewired the mains cord, disconnected all loads from the transformer secondaries and switched on.

It all seemed to be OK at first but then the power meter climbed rapidly to several hundred watts and the all-important smoke escaped from the transformer. Experience has taught me that electrical devices all run on smoke and when the smoke escapes, the device won't work any more.

I was a bit hesitant to tell this story against myself but it allows me to share what I learnt from the mistake. Basically, it's much easier to remove a transformer before washing a soiled chassis than it is to replace the transformer. **(Editor's note: it's also a good idea not to wash transformers and to use a high-voltage insulation tester to check an old transformer before applying power).**

In this case, a Philips chassis on my parts shelf had a transformer that could be adapted, even though it was about 10mm longer and needed some creative metal work in order to slip it into place. The replacement transformer produced HT voltages that were spot-on the circuit diagram values for the Tela-Verta and it had the necessary 5V and 6.3V heater windings.

The layout of this radio is quite compact (the outside of the cabinet is just 330mm wide). To leave room for the large clock mechanism, the main transformer body is located under the chassis, while the filter choke is mounted on a metal bracket above the 6-inch (15cm) Rola loudspeaker. At first glance, the choke might be mistaken for the output transformer but the latter is actually mounted to the side of the speaker.

Two dried-out Ducon electrolytic capacitors were anchored to the chassis adjacent to the speaker and wired to the choke's fly-leads. It struck me as an elegant layout, even though it was necessitated by lack of space elsewhere.

It was almost amusing, after recovering from my initial disbelief, to discover that someone had soldered a shorting wire across the choke. This indicated that the choke was open circuit and indeed it was. Shorting it out was a cheap (and no doubt convenient) way to get the radio working again but it's still a rather foolish thing to do. Valve radios are remarkably tolerant of large voltage variations but it was only by luck that the radio had survived this so-called "fix".

This rear view shows the replacement clock movement on the back of the dial plate (ie, immediately in front of the tuning gang).

The restored chassis is a neat fit inside the Bakelite case and has been fitted with a new dial cord and a new ARTS&P sticker.

Reference to the Australian Official Radio Service Manual (AORSM) indicated that the choke used in this set should have a DC resistance of 1.5kΩ. As a result, a 1.5kΩ 10W resistor was installed in its place. This resistor dropped the HT by some 30V (from 265V down to 235V).

The two replacement HT filter capacitors were installed next. These had values of 22µF and 100µF whereas the originals were 8µF and 16µF. As it turned out, the restored radio had negligible hum so the ripple filtering was excellent, even without the choke.

Three other electrolytic capacitors in the set were also replaced – one HT filter and two cathode bypasses. One benefit of removing the original transformer was that it gave access to a cluster of components that were otherwise inaccessible. These parts

During their 14-year history, Tela-Verta produced over 30 models ranging up to 8-valve console radios. This advertisement for their TV-24A mantel radio shows the same case as used for the model 204C.

included a 6kΩ 1W resistor marked with the old 1940s colour scheme and a quick resistance check revealed that it was down to just 127Ω. This resistor was included to drop the HT to the screen of the 6V6 output valve and to the anode of the 6SQ7 preamplifier.

Of course, 6kΩ is no longer a preferred value and so a 5.6kΩ 1W resistor was substituted.

Further checks revealed that the 1MΩ resistor in the AGC feedback path from the 6SQ7's detector actually measured 2.5MΩ and so it too was replaced. In addition, the 0.05μF capacitor between the secondary of the aerial coil and ground was replaced before switch on.

The Tela-Verta banner used by the D. W. Radio Company.

Switching on

At this stage, the remaining original paper capacitors were left in place but I was still optimistic that the radio would work. After warming up, it settled down to a steady power reading of 38W which looked fine. The only problem was the silence – there wasn't even a reassuring hiss from the loudspeaker.

Touching a screwdriver on the volume control wiper produced a loud 50Hz hum from the speaker, so the audio section appeared to be working (at least to some extent). Some hopeful prodding and valve substitution in the front-end then did nothing, so I was going to have to track the fault down the hard way.

Fortunately, measuring the voltages around the 6A8 mixer-oscillator quickly revealed the problem. The cathode was at 118V (circuit indicates 3V) and all other voltages were way out. This indicated that the 450Ω 6A8 cathode resistor was open circuit and that indeed proved to be the case. As a result, the cathode resistor was replaced along with its parallel 0.05μF bypass capacitor.

As soon as that was done, the radio sprang into life and I was able to tune various stations. However, the sound quality was poor and a voltage check at the top of the tone control gave a reading of 10.3V. The tone control in this radio ingeniously doubles as the grid-earth resistor for the 6V6 output valve. Replacing the leaky audio coupling capacitor between the 6SQ7's plate and the 6V6's grid brought the grid voltage back to 0V.

The 6V6's cathode now gave a reading of 5.7V and this restored negative bias to the grid. And that solved the audio problem.

Dial cord

The last remaining repair job involved restringing the dial cord. The thick, green string that someone had previously used was laughably inadequate for the job and had to be removed. Unlike ordinary string, proper dial cord will follow the rotation of the tuning shaft without binding on itself or slipping.

There was one more heart-sinking moment left. As shown in one of the photos, the ends of the chassis are acutely angled in order to clear the case. However, when I attempted to push the restored chassis back in, the mounting screws used for the replacement transformer fouled the edges. The solution proved to be quite simple – it was just a matter of cutting 3mm off the ends of the screw threads that secured the transformer, after which the case and the chassis married up.

And that was it. I now have a classic Art Deco radio that has recovered its former glory. It works well and I have the added pleasure of knowing its history. SC

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Courtesy light has insufficient delay

I built a Courtesy Light Delay kit (SILICON CHIP, June 2004) from Jaycar. When I connect it, it seems fine but it only stays on for around six seconds and then starts fading, no matter how I adjust the trimpot. Any ideas on what I did wrong? (D. P., via email).

● Check that trimpot VR1 is actually 1MΩ in value and that its resistance does change as you adjust it. The trimpot may be marked as 105 rather than 1MΩ. Also check the 470µF and 47µF capacitors as these provide the delay period.

Two Jacob's Ladder drivers in series

I built a couple of the Jacob's Ladder projects from the February 2013 issue and I am wondering whether there would be any problems connecting them in series to produce 60,000V? As well as that, I'd like to experiment with them in noble gas atmospheres. I can modify the PIC software to drive the primaries in opposite phases and I assume that this should, like any other transformers, cause the voltages in the secondaries to be in opposite phase.

This should keep the voltage versus insulation within specification, unless you know something about the ignition coils I don't. I'm going to include a safety gap (as Tesla coils have) which is very slightly wider than the display gap so the HT has somewhere to discharge, if for some reason the display gap isn't working.

I've not tested them but I presume that all three coils from the Commodore's ignition coil bank are identically wound? Any advice you have would be appreciated. (J.C., Auckland, NZ).

● It should be possible to operate Jacob's Ladders (Commodore double-ended) transformers in series, with the common connection earthed, giving a "balanced" 60kV across the outer secondary terminals. Both transformer primaries would be driven in phase.

Jacob's Ladder spark can be adjusted

I have built the Jacob's Ladder project but I cannot control the voltage (the spark). There is just one level output and it doesn't brighten or dim at all, with 8.96V to the coil no matter what I do with the VR1 pot. Could you please give me some pointers on where to fault-find for this? I have already tried changing the PIC and voltage regulator.

I would also like to know what voltages are produced from the coil (min, max) as I don't have a high voltage device to test this. (J. N., via email).

● Check that the voltage at pin 18 of IC1 varies with VR1's rotation. It could be that there is a short or open circuit to the wiper of VR1.

The voltage across the spark gap will rise to a peak of 20kV, depending on the gap length, just before the spark occurs. Then while spark current is flowing, the voltage should be in the vicinity of 2kV, depending on the spark length. We had more information on this topic in the article on measuring spark energy in the February 2015 issue.

Class-D amplifier has insufficient gain

I have built the high-power Class-D amplifier from the November & December 2012 issues and am having a problem. I am not getting the gain that I was expecting.

Connected to an iPod as a signal source, the sound is loud but only when everything is cranked right up. To be honest I thought all was well but having to open everything up to get a reasonable output seems odd, especially for an amplifier capable of

High Energy Ignition For A Vintage Car

In the article on the High Energy Ignition (SILICON CHIP, November & December 2012) it mentions the use of this system in older vehicles. My car is a vintage 1928 vehicle with a Kettering ignition system.

I note from the circuit information that it makes mention of operation when battery is low but in my case the battery obviously is always low since it uses a 6V battery. Can I expect the circuit to perform as well with 6V or are some modifications required? (G. E., via email).

● The ignition system will operate with a battery supply down to below 5V. Just how low depends a little on the particular 5V regulator and IC1's individual characteristics. However, operation to 4.5V should be expected since the PIC16F88 can operate down to 4V and the low drop-out regulator maintains 5V regulation down to about 5.2V under the low current drawn by the circuitry supplied by the regulator.

Below 5V, the output will fall but continue to supply the circuit. The "down to 4.5V operation" is based on the expected input-to-output difference of the regulator at low voltage, the operation of IC1 down to 4V and the 4V gate drive required for Q1 (the IGBT) to fully conduct.

However, there is a change that would be required for your 6V battery operation and that is the input supply measurement divider that informs the PIC microcontroller about the battery voltage. The resistive divider is set up for a 12V battery and so at 6V the dwell would be extended by up to 4x its set value. (see dwell extension with battery voltage specifications).

For 6V operation, the 47kΩ resistor from pin 13 of IC1 to ground should be changed to 180kΩ.

250W RMS. I also built the speaker protector which works fine.(C. O., via email).

- For full power output, the amplifiers needs a 2V RMS signal, ie, the maximum output of a CD player. The amplifier's gain is set by resistors R1 and Rf which should be 4.3kΩ and 68kΩ respectively for the ±50V supply version you have built. Check that these values are correct.

For higher gain, reduce the value of Rf or use a preamp. Note that a 2V sensitivity is fairly common for a power amplifier and so a preamp will normally be required to get full power when using an iPod or similar.

Small wind generator wanted

I want to build a small wind generator. I don't want to use those long aeroplane-type propellers. Instead, I hope to use the small fan blades you get with domestic electric cooling fans or extractor fans because these are easy to get and their use would not pose a hazard to anyone. They are usually plastic.

The fan blades on my roof-top water cooled air conditioner are quite small in diameter and yet they give a very powerful breeze into the house.

I was wondering if you have ever had an article on building this type of wind generator? I want to use it for battery charging. (P. C., Boulder, WA).

- We seriously doubt whether your concept is practical. This is mostly because all the fans you mention would be driven by shaded-poled AC motors and these are not suitable for generating DC currents. You would have to use a 12V permanent-magnet motor if you want to produce a small wind generator.

Also, consider how fast those fans run when they are powered. You would need gale-force winds to drive the fans at a similar speed and then you will still get much less power as a generator than when they are driven from 230VAC. Compared to that concept, a small solar panel is a much easier and more effective approach.

6V-to-12V converter for a motorbike

I would like to know if you have ever published a 6V-to-12V DC-to-DC converter. I want to convert the lighting system in a motorbike that runs on a 6V battery. (P. T., via email).

- We have not published a circuit like that although we have published many DC-DC inverters. Anything published that's rated for your application would be too large to fit in a motor bike and also not suitable for running from 6V. The power rating would probably need to be at least 200W to cater for head, tail and brake lights all being lit at the same time.

Indeed, it would make more sense to first convert the bike to run 12V LEDs for all functions, including the headlight low and high beams. If this was done, the maximum load with everything running might be only around 60-80W.

Converting the bike would involve rewinding or replacing the alternator for operation with a 12V battery rather than a using a step-up converter.

Jaycar do sell a 6V-to-12V converter (Cat. AA-0237) but it is rated at 2A. Commercial suppliers may be able to provide such a converter – see www.control-logic.com.au/products/power-supply-systems/dc-dc-converters?gclid=COGNv_evxM-MCFZcnvQodzyEAMQ)

How To Connect Multiple Computers To A Single Monitor & Keyboard

My current home office set-up includes three separate Windows computers and this is likely to increase to four in the near future. They are networked, however Windows Remote Desktop Connect and similar products contain limitations which make them impractical for controlling each or all of them from a single keyboard/monitor/mouse.

I frequently reinstall the various operating systems, during which time, of course, the networking doesn't work. (I'm a software engineer and frequently need different Windows versions and patch levels for developing/testing in different run-time environments).

I have investigated the use of standalone KVM (Keyboard, Video, Mouse) switches, however I find that the cost of the required units from established manufacturers, capable of switching DVI ports, typically runs to several hundred dollars. There must be a cheaper alternative. I have toyed with the idea of designing/building one myself, however I'm short of expertise on digital circuits.

Noting that DVI ports each have 24 connector pins and USB connectors have four, I understand from my layman's viewpoint that some of the design criteria would be that the switching ICs would need to be fast enough to support video and USB bandwidths and that some of the video lead pairs inside the box would need to be twisted to minimise interference.

Would you have any pointers, ideas or suggestions in this area (including suitable switching ICs) or would you consider designing and publishing such a project? My ideal device would: (a) be able to switch four computers, maybe expandable to eight; (b) switch a DVI-D or DVI-I connected monitor; (c) switch a USB-connected keyboard and mouse; and (d) be neat enough for desktop mounting, ie, all the cables at the rear of the box, with the switches and LEDs at the front. It could be powered from a plugpack or be self-powered from the USB port.

However, not all the computers would necessarily be switched on at the same time, therefore power would not be available from all USB ports. Switching of line-in, line-out and microphone would be desirable but not essential. (T. F., via email).

- We don't think building a 4-port KVM DVI/USB switch would be practical since it would inevitably be more expensive than buying a commercial unit. However, one of our readers may have more information on this topic.

Wants to measure audio power

I am looking for a design for an audio power meter to measure the output of several different amplifiers. My research has found an ETI design from March 1979 at www.epanorama.net/sff/Test_equipment/Meters/Audio%20Power%20Meter.pdf but the switches

Motor-Boating Problem In CLASSiC-D Amplifier

I'm seeking assistance with finding a fault in one of the CLASSiC-D modules I built for a stereo amplifier. I have constructed a huge number of amplifiers from "Electronics Australia" and Silicon Chip designs over a period of nearly 50 years (being a long-term reader of both) but this is my first attempt at a Class-D amplifier.

I have a signal tracer and multimeter and have been able to fault-find problems in anything I've managed to either (a) stuff up during the building phase or (b) blow up but this Class-D amplifier has me stumped. I built two modules, one of which works perfectly but the other is doing something unexpected.

They both work fine for the first two minutes with loads of grunt, then the left channel begins to oscillate at a frequency of about 2Hz, with the oscillations being audible as pulses with the sound switching on and off. This sounds like "motor-boating" which I haven't heard since valve amplifier days.

I know these are "switching" amplifiers but that's supposed to occur at very high frequencies – not subsonic. I also noticed that the left channel heatsink appears just slightly warmer than the right. Can you give me some idea where I need to begin looking please? (P. S., via email).

● The motor boating is a strange effect that we haven't heard of from any of our readers. Have you connected the second channel with the input inversion and subsequent reversal of the speaker wiring phase to compensate? It may be just a supply pumping effect causing the motor boating (over voltage cut-out) if this is not done.

Otherwise, you are fortunate to have one working amplifier so that you can compare the voltages between them. Chances are that the peak over-current setting, supply detection or temperature detection voltages (possibly due to resistor values) differ in value in the motor-boating amplifier compared to the good working amplifier.

You can check the voltages in both amplifiers with power applied but no input signal present.

for this are hard to obtain and very expensive.

I have also looked at the Circuit Notebook design in the October 2009 issue of Silicon Chip. This is a possibility but would require duplication to measure both channels of a stereo amplifier simultaneously. Also, I don't know how to determine the maximum power this meter could handle.

There are also designs which use a bank of LEDs but these do not provide the sort of definition I am seeking. Ideally, I would like to use a digital panel meter like the Altronics Q0571.

Have you published anything like I am seeking or do you know of anything that I could use? (B. D., via email).

● If you do a search on our website you will find we have described three AC Millivoltmeters, in 1988, 1998 and 2009. The one most appropriate to your application is the one described in October & November 1998. It can measure in six ranges from 2mV to 200V and uses a digital panel meter.

However, the originally specified meter panel is no longer available and neither Altronics nor Jaycar have a panel meter with the same specifications as the article. Fortunately, the Altronics Q0571 can be used with the following changes to the October 1998 circuit:

(1) Change ZD1 for a 5.1V type (1W) and the 470Ω resistor to a 1W rating. The 9V supply now becomes about 5V for the meter and IC8.

(2) Pins 5 & 12 of the Q0571 connect to circuit ground.

(3) The output from IC7b (a voltage level shifter) is no longer required. Instead, the 910kΩ resistor in parallel with the 100kΩ resistor which previously connected to pin 7 of IC7b now connects to pin 1 of IC7a, with an additional 10kΩ resistor to ground.

(4) The tap-off point for the divider at the junction of the 10kΩ and the paralleled 910kΩ and 100kΩ resistors becomes the voltage signal that's applied to the pin 6 input of the Q0571 panel meter.

(5) Pins 13, 1 & 3 of IC8 connect to pin 10 of Q0571. This is the inverse backplane signal to drive the decimal points when connected to a Decimal Point input.

(6) Pins 5, 2 & 12 of IC8 are left open and this has the Decimal Point off. An internal high-impedance connection to the LCD's backplane keeps Decimal Points off when a DP input is open.

(7) It also seems that the Q0571 does not have a reference out at pin 3 and so reference in at pin 4 needs to be set. You could use a resistive divider across the 5.1V supply for a 200mV reference.

This could be a 10kΩ resistor in parallel with 390kΩ from the 5.1V supply and joined to a 390Ω resistor that connects to ground. The voltage across the 390Ω resistor should be close to 200mV and is connected to the LCD's pin 4. Pin 11 of the Q0571 should also connect to ground.

Note that for valid power measurements, an amplifier must be driving a nominal load. This can consist of a high-power 4-8Ω resistor.

Speed controller has no control

I purchased the May 2009 Motor Speed Controller kitset from Jaycar (KC5478) to control the speed of a 60W motor on a profile cutter. I have assembled the kit and it runs the motor but there is no speed control.

I have visually checked all the components and they all appear to be in the right way around. I'm not sure what to look for next. Any help or suggestions would be much appreciated. (S. B., via email).

● Check how the speed potentiometer is wired between the pot and PCB. Also check all other mains wiring to make sure it is correct.

PIC programmer is obsolete

I have successfully made and used the Portable PIC Programmer (Silicon Chip, September 2003) and recently I've made the GPS Tracker unit from the November 2013 issue. With the 28-pin header, would the PIC Programmer be able to program a blank PIC32MX250-128B as used in the GPS Tracker to incorporate the latest software update?

If not, can you suggest a suitable "out of circuit" programmer that will? (J.A., via email).

● The portable PIC programmer is

too old to program PIC32s. We haven't made a suitable programmer since 2003 as it is too hard to keep up with all the new devices – we'd need to revise it every year.

We suggest that you refer to the Micromite article in January 2015 for information on how to program a PIC32 out of circuit. All you need is a Microchip PICkit3 and a simple programming adaptor board which can be done on breadboard or (the way we prefer it) with a ZIF socket soldered on a piece of protoboard, with a few extra components (ie, bypass capacitors and a programming header).

Pump switching timer query

I write in relation to the "Programmable Mains Timer" project (SILICON CHIP, November 2014) which has caught my eye. My Dad is currently using an old SCC-style time clock installed in his power box to control when the swimming pool filter turns on and off. My query is whether this project could be used as a modern replacement for the older time clock with an electrician installing it in the same location?

If it can't be used for this purpose, is there any way it might be adapted for such a use? The existing time clock is "hard wired" via its own fuse and has an override switch under the pool at the deep end where it connects to the pump. (P. M., Karabar, NSW).

● The timer can be set to switch on and switch off once each within a day, and repeat each day.

The mains switch itself is a UHF remote controlled commercial unit. You will need to check if the mains switch is capable of switching on the pool filter motor. These tend to be 10A rated but this may not be sufficient for the start-up current of the motor.

The start-up current can be much greater than 10A and the relay contacts of the UHF mains switch may not last long with this type of load.

LM3914 ohmmeter circuit wanted

Was there ever a circuit published for an ohmmeter using an LM3914? (B. C., via email).

● We published an insulation tester in May 1996 that measured resistance in Gigaohms and displayed the result using an LM3915. The LM3915 is essentially the same as an LM3914 except for its logarithmic rather than linear scale. The basic circuit arrangement could be used for ohms measurement with a lower test voltage.

Replacement For Honda Quad Ignition

I have a question about your new Multi-Spark CDI system. I have a Honda Quad of 1992 vintage which has a failed ignition unit and I understand it's an inverter type unit. The triggering is by a reluctor type coil on the alternator.

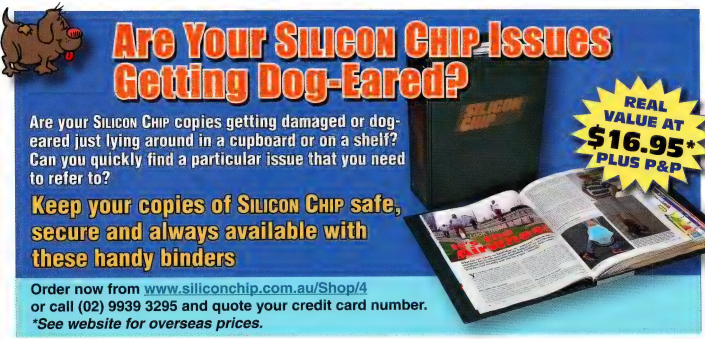
Can I use your new ignition design to replace the original unit and if so, what will be the size of C1 for a single cylinder motor? (M. P., via email).

● It would appear that your Honda quad is using a capacitor discharge unit. To be more specific, your ignition is more likely a magneto ignition with high-voltage coil on the alternator. We published a replacement CDI unit that may be suitable in May 2008. Our Multi-spark CDI system is not suitable.

Query about ultrasonic cleaner

Some time ago, you published an Ultrasonic Cleaner (SILICON CHIP, August 2010) where the transducer was attached to a suitable container and away one went. From what I remember, the primary of the transformer was a centre-tapped feed unit with Mosfets alternately switching either side to ground. The secondary simply hooked up to the transducer.

Anyway, from what I could tell there was no means by which the volt-seconds of the two sides of the primary was measured and compared, so how did the circuit deal with the possibility of staircase saturation of the transformer core? I am still a bit



Help Needed With Motor Speed Controller

I need a little help with the May 2009 230VAC Full-Wave Motor Speed Controller. In short, it doesn't work!

I have done all the tests with a 12V supply and I get 12.4V at the relevant pins (my supply is 12.8V) on all ICs, however I do not get any voltage changes at VR1 or at the gate of Q1. Pin 7 of IC3 is 4.1V, pin 7 of IC1 does not change from 12.4V, the gate of Q1 remains at around 300mV and there are no shorted diodes.

Please be aware that I used to assemble circuit boards in my job so I do know how to solder and the correct orientation of components and also I have checked every joint on the board more than once. I am not an electronic technician however and don't really understand the technical terms referred to in the test procedure, eg, measuring the triangle wave.

- Check the wiring to speed pot VR1 since it may be wired incorrectly if no voltage change is measured at the wiper when the pot is rotated.

A 12.7V output at pin 7 of IC1 but only 300mV at the gate of Q1 suggests a problem with IC2 or transistors Q2 & Q3. If you are using a socket, check that none of the pins is tucked under the IC, thereby preventing connection.

A measurement of the triangle wave using a multimeter set to DC will show a reading of about half supply (about 6V in your case). This can be measured at pin 10 of IC1.

new to switchmode supplies so I may be missing something. (G. C., Cannington, WA).

- The transformer is driven with a symmetrical drive to the two separate halves of the primary. Also the primary windings are made bifilar so they are symmetrical. When using matching Mosfets, there is generally no extra precaution necessary.

Typically, SMPS designs use the above principles and there is no practical staircase saturation effect.

More information is available at http://caxapa.ru/thumbs/348441/Switchmode_Power_Supply_Handbook_3rd_edi.pdf

LEDs used as sensor in solar tracker circuit

In the Ask Silicon Chip pages for December 2014, a reader was advised to consider a Solar Panel Tracker circuit using LEDs from the May 2009 issue. However, I have a few questions about it. What is the dotted line between pin 10 of IC3 and ground which has what appears to be a capacitor symbol in it, although no values are given?

Are the A and K labels transposed for both strings of three LEDs and are LEDs 4, 5 & 6 shown the right way around, or is the circuit correct? (M. M., via email).

- It seems as though any mention of the dotted capacitor has been accidentally omitted from the article and unfortunately we do not have the original material. We would suggest that a 0.1µF capacitor or similar value could be fitted to provide a degree of input filtering.

And although it may look wrong, the six green LEDs are shown correctly – they are being used as sensors to generate voltage in response to light.

Problem with 10V reference

I have constructed the 10V Precision Reference as modified in the August 2014 issue and despite the apparent simplicity of the device I am embarrassed to say that I'm having trouble with it. If I've done something stupid I can't figure out what it is.

There are two problems. Although the Reference does give 10V, it only stays on if the Start switch is held down. Once released, the Reference turns off in about 1.5 seconds.

I have tried different values of resistor (specified as 2.2MΩ) and tantalum capacitor (specified as 47µF) in the time-delay circuit and although I can shorten the "on" time to be almost instantaneous disconnect when the switch is released, I have been unable to increase it. However, the fact that I can affect it at all suggest that the time delay circuit is doing something, which would seem to eliminate problems such as shorts.

The Reference gives 9.98V as measured by my UNI-T DVM, which agrees quite closely with my other meters. When I fitted the 2.2kΩ and 6.8kΩ resistors and the 1kΩ trimpot, I had to wind the trimpot all the way to one end to get 10V. It would not adjust to above this value.

I have done all the obvious things, checked all component values, checked the PCB for both continuity and shorts, re-examined everything multiple times and I'm completely baffled. (B. D., Hope Valley, SA).

- We agree that your first problem is puzzling. The fact that the delay circuit does seem to be working in a fashion suggests that there is a much lower effective decay resistance path than provided by the nominal 2.2MΩ resistor. Possibly Q1 has leakage between its gate and source or there is some sort of hidden leakage path between pins 6 & 8 and pin 7 of the original timing chip socket.

Your second problem suggests that your AD587KNZ device is at the lower end of its untrimmed tolerance range. In such a case, it would be OK to shunt one or both of the fixed resistors in series with the 1kΩ trimpot with higher values, to bring down their values by a tad and thus give the trimpot a slightly wider adjustment range. Try shunting the 6.8kΩ resistor with a value of 100kΩ.

Wideband oxygen sensor query

I have some questions concerning the Wideband Oxygen Sensor Controller Mk2 from the June 2012 issue. Is the aim of this design to feed the car's ECU with a more accurate signal to better fine-tune the engine or is it mainly aimed at allowing a readout to be fitted to a narrow-band sensor? In other words, are there any advantages in employing this controller over the standard narrow-band sensor?

Putting it another way, is the simulated narrow-band signal improved or shaped in any way to the ECU. For example, instead of oscillating back and forth between 0.2V and say 0.7V, do you average its value in the centre a little more to give a more constant signal to the ECU? I thought this might be an advantage to do so, even if a very small advantage.

Can the circuit feed a more conventional looking gauge rather than

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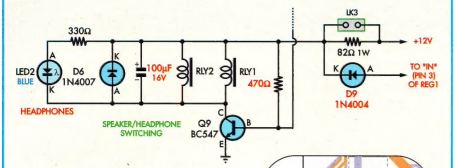
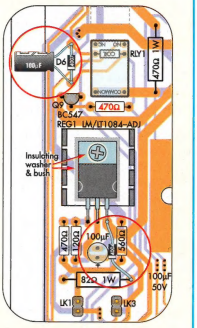


Currawong 2 x 10W Stereo Valve Amplifier (November 2014 - January 2015): the relays intended to switch the signal over from speakers to headphones do not operate correctly. Three components must be changed or added to fix this and these changes can be made without removing the PCB from the case.

The accompanying two diagrams show the modifications to the circuit and PCB in red. The 10kΩ resistor can simply be shunted with a 470Ω resistor. The added capacitor is shown on its side for clarity however it should go above D6. Make sure the leads of the added diode can't short to the leads of the 560Ω resistor or pin 2 of REG1. With these changes, the relay holding voltage is around 3.6V which is sufficient.

Finally, in the parts list on page 35 of the November 2014 issue, the 8 x 220µF 630V polyester capacitors should be 8 x 220nF 630V instead.



Ask Silicon Chip

. . . continued from page 102

the digital display included in the project? Perhaps something off eBay? A bargraph or rotating dial pointer is quicker to read at a glance, especially if the value is constantly changing – it's the old analog clock-face or speedo versus a digital fast changing numbers readout thing. (S. S., via email).

- The signal presented to the ECU is a narrow-band oxygen sensor simulation that is derived from the wideband sensor readings. So the ECU is not fed anything different to what it is designed to receive – a standard narrow-band signal that has a sharp change in voltage at stoichiometric mixtures.

We don't alter the narrow-band response from that obtained via the wideband sensor. We did try incorporating a small amount of averaging of the signal during project development but that slowed down the overall sensor response signal applied to the ECU. Also, we do not alter the oscillating voltage narrow-band signal as the ECU is expecting a signal that will switch sharply in voltage about the stoichiometric point. Any smoothing or voltage range restriction can cause the ECU to present an error code due to the sensor not producing the expected signal.

Note that the voltage range from the simulated narrow-band sensor output at the sharp transition about stoichiometric still represents a very small mixture change even though the voltage range varies by several hundred millivolts from 0.45V.

The wide-band sensor allows for an accurate mixture reading to be observed. You can use an analog meter if it can be arranged to operate over a 0-5V range. 0V represents a lambda of 0.7 and 5V a lambda of 1.84.

Query about phase splitter circuit

I have noticed an error in the main circuit diagram of the Currawong valve amplifier in the November 2014 issue. The phase splitter has unequal resistors (120Ω and 220kΩ) in the anodes. From the text, I guess that both should be 220kΩ. (J. G., via email).

- It may look incorrect but it's not. After a lot of experimentation, we found that this configuration gave the best symmetrical drive to the output valves. SC

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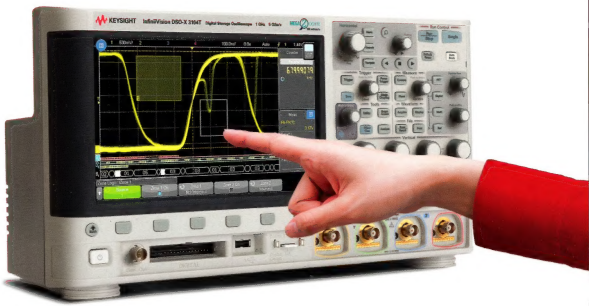

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